SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXX]
NUMBER 2077]

NEW YORK, OCTOBER 23, 1915

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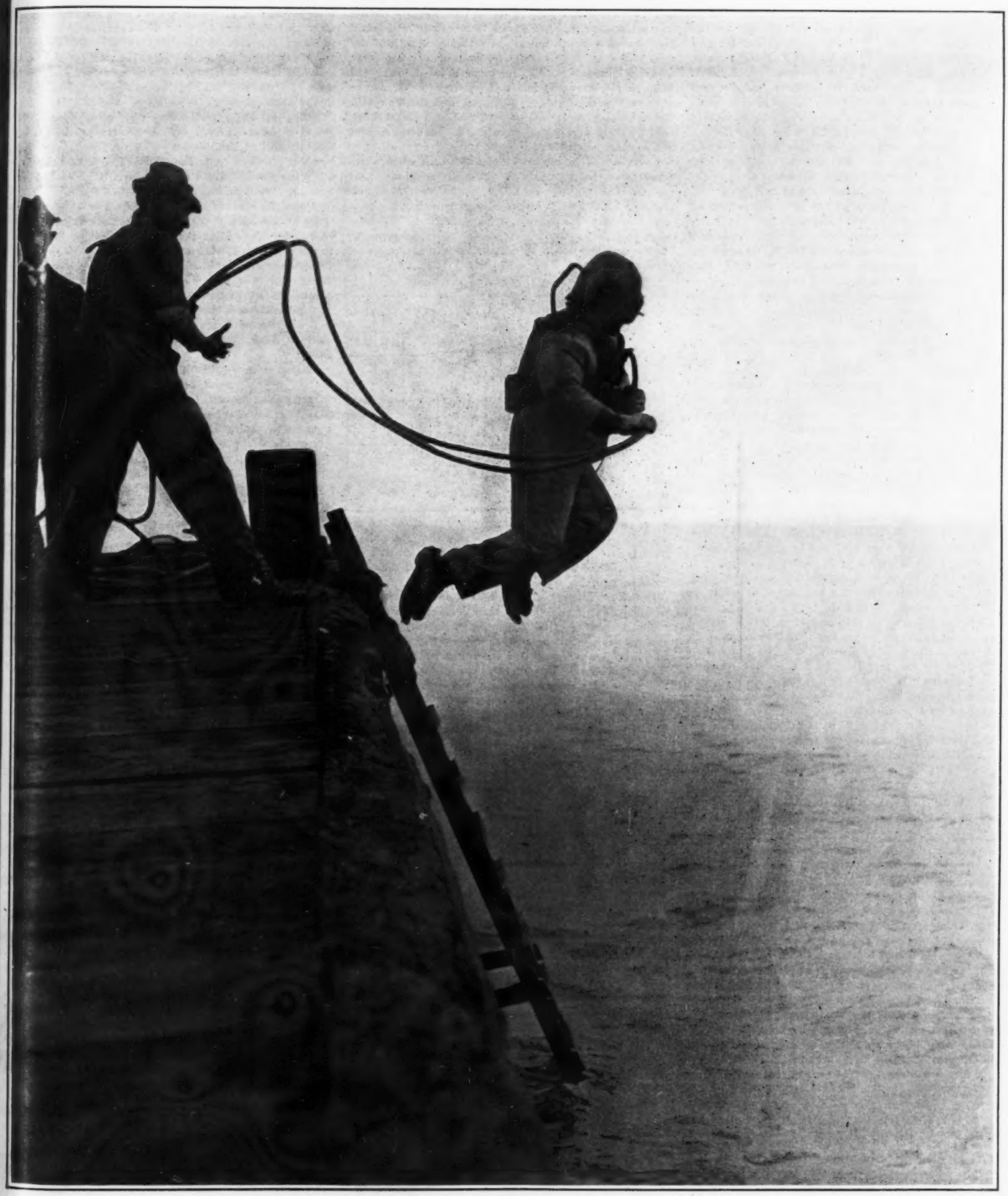

A diver in full costume making a sensational descent.

DYNAMITING A DERELICT.—[See page 261.]

Solar Radiation*

New Evidence on the Intensity of Radiation Outside the Atmosphere

By C. G. Abbot, F. E. Fowle, and L. B. Aldrich

In Volume III of the *Annals* of the Astrophysical Observatory of the Smithsonian Institution, we published the methods employed, the apparatus used, and results obtained in determinations of the mean intensity of solar radiation outside the atmosphere during the years 1902 to 1912. The method employed was that of Langley.[1] It requires measuring the intensity of the total radiation of the sun with the pyrheliometer and also the measurement of the intensity of the rays of the different wave-lengths with the spectro-bolometer. Measurements of both kinds are made repeatedly during a clear forenoon or afternoon from the time when the sun is low until it becomes high or *vice versa*. In this way we determine how rapidly the rays of the sun as a whole and of individual wave-lengths in particular increase in intensity as their path in air diminishes. From this we estimate the total intensity of the solar radiation outside the atmosphere altogether.

There are certain parts of the spectrum where by reason of powerful selective absorption of rays by water vapor and other terrestrial atmospheric vapors and gases, sufficiently accurate atmospheric transmission coefficients cannot be determined in this manner.[2] This offers no great difficulty, for, with Langley, we assume that these absorption bands would be absent outside the atmosphere. Hence, the intensity of these parts of the spectrum outside the atmosphere can be determined by interpolation from the intensities found on either side of them.

Whatever the value of the atmospheric extinction of solar rays, all good solar constant work depends on accurate pyrheliometry expressed in standard calories.

During the investigation we devised two forms of standard pyrheliometer on quite different principles. These instruments agree with each other to within 0.5 per cent, and they yield values of the solar radiation ranging from 3 to 4 per cent above those found with different copies of the Angström pyrheliometer. This latter instrument was adopted as the international standard for the measurement of radiation by the meeting of the International Meteorological Committee held at Southport in the year 1903 and by the International Union for Solar Research at its meeting at Oxford in the year 1905. Mr. A. K. Angström has, however, lately pointed out that the Angström instrument is subject to slight errors which cause it to read about 2 per cent too low, according to his opinion. If so, this brings the scale of the Angström within less than 2 per cent of the scale of the Smithsonian Institution. The latter scale is fortified by the fact that in our several standard pyrheliometers it is possible to introduce and determine test quantities of heat. This has been repeatedly done in each of these instruments, and the test quantities of heat have been recovered to within 0.5 per cent.

The following table gives the results of nearly seven hundred measurements of the solar constant of radiation as published in Volume III of the *Annals* above cited:

TABLE I.—*Mean Solar Radiation Outside the Atmosphere*

Expressed in standard 15° calories per square centimeter per minute at mean solar distance

Station	Washington	Bassour	Mt. Wilson	Mt. Whitney	Total
Years	1902–1907	1911–1912	1905–1912	1909–1910	.....
Altitudes (meters)	10	1,160	1,730	4,420	.....
Observations	37	82	573	4	696
Mean result	1.968	1.928	1.933	1.923	1.933

The Washington results fall a little higher than the others. This may be due, in part at least, to the fact that most of them were made while sunspots were numerous, for our investigations at Mount Wilson indicate that high values prevail when sunspots are at a maximum.

Our determinations rest on the assumption that for all excellent days the atmosphere may be regarded without sensible error as made up of layers, concentric with the earth, which may differ in transparency from layer to layer in any gradual manner, but which, within the time and space covered by a solar beam during a single morning of observation, are for each layer by itself sensibly of uniform transparency. As the relative transparency of the several layers is not assumed to be known, it is convenient to limit the duration of a single series of observations to the time interval during which the solar zenith distance is less than 75 degrees. During this interval the rate of decrease of path of the solar beam in the atmosphere, with decreasing solar zenith distance, is sensibly the same in all the supposed atmospheric layers, and is proportional to the change of the secant of the zenith distance. For greater zenith distances than these this proportionality does not hold, because the influences of curvature of the earth and of atmospheric refraction.

A variety of conditions of observation were encountered; first, as regarding the intensity of sunlight at the observing station; second, as to the effect of atmospheric humidity on the infra-red spectrum; third, as to the effect of dust upon the visible spectrum. We draw attention to the close agreement of the solar constant values obtained in these contrasting circumstances of observation.

TABLE II.—*Variety of Conditions of Observation.*

Place	Barometer	Date	Temperature	Atmospheric water vapor pressure at station	Precipitable water[3]	Radiation observed Zenith distance 60^0	Transmission coefficient Wave length $\lambda = .50$	Corrected solar constant
	cms.			*mms.*	*mms.*	*calories*		
Washington	76.5	Feb. 15, 1907	3.0	1.45	4.8	1.352	.837	1.872
		May 14, 1907	29.0	14.60	22.6	0.939	.626	2.034
Bassour	66.3	June 9, 1912	14.0	6.94	12.6	1.302	.855	1.903
		July 26, 1912	26.0	5.36	11.9	0.960	.684	1.915
Mt. Wilson	62.5	Aug. 21, 1910	23.0	7.39	22.5	1.198	.852	1.933
		Aug. 21, 1911	23.0	2.50	11.2	1.370	.843	1.944
Mt. Whitney	44.7	Sept. 3, 1909	1.0	1.97	(0.90)	1.560	.905	1.951
		Aug. 14, 1910	2.0	2.05	0.60	1.607[4]	.933	1.943[4]

From the foregoing the reader may see that the soundness of the theory of the atmosphere extinction of radiation employed by us is supported by the fact that its application to observations made under widely diverse conditions yields nearly identical values of the intensity of solar radiation outside the atmosphere. Nevertheless, it is maintained by some critics that our estimate of the atmospheric extinction is less than half large enough.

In further support of our values of atmospheric transmission, we call attention to their connection with Lord Rayleigh's theory of the scattering of light by molecules and particles small as compared with the wave-length of light. According to this the exponent of scattering varies inversely as the fourth power of the wave-length, and thus the product of fourth power of wave-length by logarithm of transmission coefficient should be constant. As shown by one of us,[2] the coefficients of atmospheric transmission obtained on Mount Wilson depend slightly on the total atmospheric humidity included between Mount Wilson and the sun. The transmission coefficients may be reduced to dry air conditions by applying a very small correction to them. These corrected coefficients are found to be in close harmony with Lord Rayleigh's theory.

By the aid of Lord Rayleigh's theory of the scattering of light, Mr. Fowle has determined from the Mount Wilson experiments the number of molecules per cubic centimeter of dry air at standard temperature and pressure. He finds the value $(2.70 \pm 0.02) \times 10^{19}$, while Millikan obtained, by wholly dissimilar methods, $(2.705 \pm 0.005) \times 10^{19}$.

In the course of our experiments at Mount Wilson, we found the solar radiation outside the atmosphere variable in short irregular periods of from five to ten days, and to have a variable range of from 2 to 10 per cent. That this variability is really solar was confirmed by independent simultaneous observing at Bassour, in Algeria, and still more recently by as yet unpublished experiments on the distribution of brightness over the sun's disk. This latter method is quite independent of atmospheric disturbances. It seems to us that if our solar constant results were erroneous to the extent that the solar constant is really 3.5 calories instead of 1.93, as some of our critics would persuade us, the probability of finding these real solar variations of from 2 to 10 per cent by simultaneous observing at stations separated by one third of the circumference of the earth would be very small. We should suppose that if there are atmospheric conditions which lead to our underestimating by nearly 50 per cent the intensity of solar radiation outside the atmosphere, these would probably be variable from day to day; so that such minute real changes of the total intensity of the sun's radiation as we have found would have been swallowed up in the irregular local fluctuations of the transparency of the atmosphere.

Nearly all the pyrheliometry now being done in the world is done with Angström, Marvin, Michelson, or Smithsonian pyrheliometers. These represent five independent attempts to fix the standard scale of radiation. They have been many times compared with each other, and are found to accord within less than 4 per cent, and now, in view of A. K. Angström's researches, perhaps to less than 2 per cent. Of these scales of pyrheliometry, ours gives the highest readings. We have devoted much experimenting during many years to the establishment of the standard scale of pyrheliometry. Many observers reduce readings obtained with other pyrheliometers to the Smithsonian scale. Dr. Hellmann has indeed gone so far as to say publicly[4] that there is but one standard pyrheliometer, and that is at the Astrophysical Observatory of the Smithsonian Institution.

COMPARATIVE RESULTS OF PYRHELIOMETRY AT REDUCED ATMOSPHERIC PRESSURES.

In a recent publication, Prof. H. H. Kimball gives the highest value of solar radiation ever observed at Washington, for zenith distance 60 degrees, as 1.51 calories per centimeter² per minute, observed on December 26th, 1914. Reduced to vertical sun and mean solar distance, this result would have been about 1.58 calories.

The highest values observed on Mount Wilson are those of November 2nd, 1909, and yield to a similar reduction 1.64 calories, at mean solar distance and vertical sun.

For Mount Whitney, for the maximum obtained on September 3rd, 1909, the reduced value is 1.72 calories at mean solar distance and vertical sun.

In balloon flights of August 31st, September 28th, and October 19th, 1913, Dr. A. Peppler of Giessen observed with an Angström pyrheliometer at great altitudes. On September 28th the results were, in his opinion, vitiated by a defect of the apparatus. On August 31st, the highest result, as reduced by Peppler to the Smithsonian scale of pyrheliometry, was 1.77 calories, obtained at zenith distance 45 degrees, altitude 5,900 meters, air pressure 36.5 centimeters. This result, however, is not a complete Angström measurement depending on "left, right, left" readings, and therefore may be vitiated by galvanometer drift. Moreover, it stands very high as compared with others of that date, and, indeed, much higher than others of that date obtained at greater altitudes. On October 19th, the highest complete result was 1.67 calories, obtained at zenith distance 61 degrees, altitude 7,500 meters, air pressure 29.8 centimeters. This result is in good agreement with the others of that date. Peppler regards the results of October 19th as his best. When reduced to zenith sun and mean solar distance, the result of October 19th comes out about 1.755 calories per centimeter² per minute.

These direct observations from manned balloons are very meritorious, and of course entitled to far greater weight than those obtained at similar altitudes in our free balloon work at Avalon, in 1913. Hence, although our results there were in complete accord with Peppler's, we have not thought it worth while to give them.

It seems to us that, with the complete accord now reached between solar constant values obtained by the spectro-bolometric method of Langley, applied nearly one thousand times in ten years, at four stations ranging from sea level to 4,420 meters, and from the Pacific Ocean to the Sahara Desert; with air-masses ranging from 1.1 to 20; with atmospheric humidity ranging from 0.6 to 22.6 millimeters of precipitable water; with temperatures ranging from 0 deg. to 30 deg. Cent.; with sky transparency ranging from the glorious dark blue above Mount Whitney to the murky whiteness of the volcanic ash filling the sky above Bassour in 1912, it was superfluous to require additional evidence.

But new proofs are cited above. These give the re-

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* Notes from *Smithsonian Miscellaneous Collections*, Vol. 65, No. 4.

[1] "Report on the Mount Whitney Expedition," Professional Papers, Signal Service, No. 15, pp. 135 to 142, and table 120, values 1 to 5.

[2] Investigations of Fowle showed, however, that transmission coefficients can be obtained even in the great infra-red bands of water vapor, whose employment would practically obliterate the bands outside the atmosphere. Hence, we may conclude that if there are diffuse atmospheric bands not easily recognizable, they will be almost exactly allowed for by ordinary transmission coefficients. See *Smithsonian Misc. Coll.*, Vol. 47.

[2] This value is corrected as suggested in note 2, Annals III, page 113.

[3] Determined by Fowle's spectroscopic method, and gives the depth of liquid water which would result if all the atmospheric water vapor above the station should be precipitated. Experiments of 1913 show close agreement of this method in its results with those obtained for the same days by integration of humidity observed at all altitudes by sounding balloons.

[3] F. E. Fowle, *Astrophysical Journal*, 38, 392, 1913; 40, 435, 1914.

[4] Bericht über die Erste Tagung der Strahlungskommission des Internationalen Meteorologischen Komites in Rapperswyl bei Zurich, 2 September, 1912.

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sults of an independent method of solar constant investigation. In this method the observer, starting from sea level, measures the solar radiation at highest sun under the most favorable circumstances, and advances from one level to another, until he stands on the highest practicable mountain peak. Thence he ascends in a balloon to the highest level at which a man may live. Finally, he commits his instrument to a free balloon, and launches it to record automatically the solar radiation as high as balloons may rise, and where the atmospheric pressure is reduced to the twenty-fifth part of its sea level value. All these observations have been made. They verify the former conclusion; for they indicate a value outside the atmosphere well within the previously ascertained limits of solar variation.

Our conclusion still is that the solar constant of radiation is 1.93 calories per square centimeter per minute.

Aerial Warfare and the Weather

Conditions That Affect Various Classes of Aircraft

ALL trades carried on outdoors—and that of the fighting-man is no exception—are bound to keep a very watchful eye on the weather. There are many famous instances where the state of the weather has proved to be the deciding factor that spelt rout and ruin for one side, and victory for the other. Some of the famous instances of this interposition of the elements have been the dispersal of the Greek fleet after the fall of Troy, the wreck of the Spanish Armada, and the failure of Napoleon's invasion of Russia.

Modern armies have means of combating adverse conditions of the elements unknown earlier. But on the other hand, the present war has developed a new branch of the service—that of the aerial corps—which is peculiarly susceptible to interference by adverse conditions of the weather. It is a very few years indeed since the most experienced airmen then existing would wait for hours before essaying flight till the wind was just right, though impatient crowds jeered at the delay. But amid the desperate chances that are the common place of a soldier's life the braving of the elements in a flimsy bit of wood and silk is frequently the less of two dangers.

As a result there has been much valuable information gained as to the way in which varying conditions of wind, temperature, etc., affect aircraft of different sorts. The subject is ably treated by Lieut. Metz of the German army in *Umschau* (Berlin) of June 17th. We read:

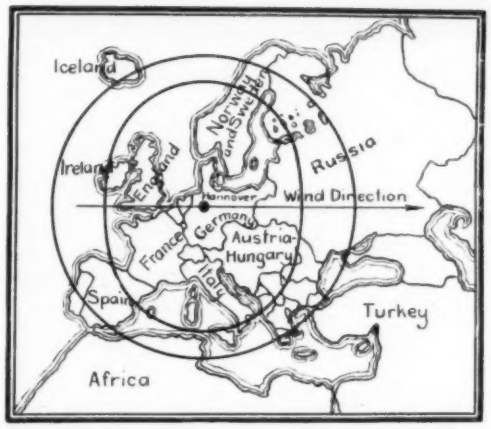
The war aircraft in use in the present movement comprise three principal kinds, the captive balloon, the dirigible airship, and the aeroplane, while the free balloon has thus far not been employed. The captive balloon, which is used in all armies as an important means of observation—especially for the artillery—is nothing but a free balloon secured by a cable. But in the course of time, because it pulled and struggled at its ropes so much, so that its occupants suffered from seasickness, it has been given a longer form, with an air-bag at one end. This has given it a greater stability so that observation from it is possible even in quite high winds. It may be mentioned here that until shortly before the war the French gave preference to the spherical form for captive balloons. During the war, however, the German form appeared at important points. This can be imperilled chiefly by sudden gusts of wind, which break its cable, a particularly unpleasant accident, since this usually throws important secret observations into the hands of the enemy.

Far more important are storm conditions to a dirigible. While in general the climatic conditions of a country, known by years of observation, are of decided significance, and the equipment and care of troops, etc., must be governed by them, in many cases a condition of storm which suddenly arises, or a sudden change of weather may be decisive factors in determining the result of military operations. Slight as such a thing may appear in the records of meteorologists and climatologists, it may be of violent effect on the activities of the air fleet. How much this is still the case in spite of all progress in this direction is sufficiently proved by the catastrophies to many of our marine airships on the Danish coast around the period of the equinox.

The dangers that may accrue to an airship from bad weather comprise various factors, according to Lieut. Metz. Thus an aerostat, i. e., a machine filled with gas lighter than air—in order to be of military use must not only be able to remain at such height as is required for a considerable length of time, but must also be able to return safely to its hangar. But at a height of from 1,500 to 2,000 meters (4,875 to 6,500 feet) an airship loses a great deal of gas, and temperature plays an important part here.

In warm air the gas in the ballonets expands. Every one has observed that free balloons are not pumped full before they go up. In the higher strata of air the gas expands because of the lessened pressure. In course of time some gas escapes, and in order to maintain the same height it is necessary to throw out ballast. This does not apply exactly to motor-driven aircraft, however. Though gas is lost when traveling at high altitude, the steady consumption of fuel and the loss of weight due to the throwing of bombs permit of a long cruise at a great height without the discarding of much ballast. A degree of compensation for the expansion of the gas results also from the fall in temperature due to ascent, which equals about 0.5 deg. to 0.8 deg. Cent. for every 100 meters (328 feet). But change of temperature may always be a source of danger. If, for instance, an airship rises in direct sunlight the gas may be warmed up to 40 deg. Cent.—and if this occurs at great heights a serious loss of gas is unavoidable.

If the airship does not return to its shed till after nightfall these may be the following result: The earth is much cooled, the warm air has risen, the dirigible comes on at normal speed and sags on entering the cooler layers of air because of the sudden contraction of the gas. If by an unlucky chance ballast is not thrown out fast enough, or the men below do not catch the ship, then the longitudinal ribs may be broken if no worse mishap befalls.



Radius of action of a modern airship with Hanover as a base. Outer circle in still air. Elipse with wind in direction of arrow.

Obviously, therefore, it is best to ascend at end of night rather than *vice versa*, since as day advances the warmer air will expand the cooled gas and give it more lifting power. It is clear, too, that this circumstance is of the greatest importance in the nocturnal expeditions of our Zeppelins against England. Their success in the present warm season shows this view to be correct. This is equally true for all systems. Though there is no breaking of ribs in the non-rigid ships, the gondola with its valuable machinery may be destroyed.

Lieut. Metz next discusses the obvious difficulties of orientation at night and in obscure weather caused by low-lying clouds, fog, rain and snow, but remarks that these very conditions favor safety in making raids and ease of escape from stronger and faster foes. Wind, too, is a great source of danger, but so long as the ship is in the air wind can do little harm unless it has greater velocity than the dirigible itself. In that case destruction is pretty certain. It also has an extremely unfavorable influence on the ship's radius of action. The accompanying map shows that while this "action radius" is a circle in still weather it becomes an ellipse in windy weather.

If a dirigible travels from *A* to *B*—at say 288 kilometers apart—and it has a speed of 20 meters per second, then it will cover this distance in calm weather in about 4 hours. If there is a headwind of 10 meters per second then the ship will travel only 10 meters per second and will require 8 hours to cover the same distance. In the first case the return trip will take the same time as the outgoing journey. But with a ten-meter wind behind it the return trip can be made in 2 hours and 36 minutes. From this we see the advantage of having fast ships, since the weaker the ship the worse the effect of the wind.

One other danger may arise from wind, i. e., when it is perpendicular to the hangar. In such an event it is often impossible to take the dirigible in or out of the house, and it must perforce be anchored. In such circumstances many Zeppelins have already been destroyed by the ship's back being broken, or its being torn loose from the cable. Rain and snow burden an airship with tons, weighing it to the ground, or hurling it against hills and houses. A thunder-storm, too, may annihilate it and its crew by a stroke of lighting, even without this extremest misfortune the effect of such a storm is always to interrupt wireless communication with the land.

Lieut. Metz adds that the steady perfecting of the aeroplane, both of the motor and of the construction, have made it almost independent of the weather. The success of the aviator depends on the faultless functioning of his motor, and weather can exert a decisive influence upon it only through severe cold.

A New Mastodon

THE preparators and aids in the section of Vertebrate Paleontology of the United States National Museum are busy putting together the bones and fragments of a huge skeleton of a mastodon recently secured near Winamac, Indiana, by the assistant curator of fossil mammals, Mr. James W. Gidley.

Nearly a year ago a mastodon skull and several other bones were dug up by a steam shovel in the course of constructing a drainage ditch in a swampy deposit on the farm of Messrs. H. H. and W. D. Pattison, several miles northwest of Winamac, Indiana. These bones were generously donated to the United States National Museum by the Pattison Brothers, with the privilege of making further search if desired, and it was soon decided that a further search would yield valuable results. The remains of this monster were found in good condition, although near the surface, having lain without being disturbed for thousands of years in marly deposits of an ancient swamp.

A small appropriation was secured for further excavation in the locality of this find, with the result that Mr. Gidley has just returned with nearly all the other bones of this gigantic mammal. Practically a complete skeleton was found, except two large limb bones, many of the foot bones, and the tusks, for which a further search may soon be made. When mounted the Museum will possess one of the most complete specimens of this great beast of the ages just preceding the present. There is a small mastodon specimen in the Museum collections secured in 1901 from the peat deposits near Church, Michigan, but the new one will overshadow it by over two feet in height and several hundred pounds in weight. It is believed that this skeleton will stand full ten feet high. The fine state of preservation of the bones is due to the fact that it has lain continuously since its entombment beneath the water level of the swamp, and thus has not been affected by the oxidizing action of the air. Mr. Gidley feels certain that with patience and by draining the ditch the missing portions of the skeleton will be found.

The specimen is believed to be that of a full grown male, although not an old individual, who lived in the Pleistocene age, probably 150,000 years ago. This animal, while it is related to the elephant family, differs in general proportions of the skeleton and through the character of its teeth, which unlike the flat grinding ones of the elephant, are more of a rugose type with pointed corrugations calculated to have been used in crushing as well as grinding the coarse vegetable food on which it lived. The largest of the teeth measures nearly seven inches in length and is about four inches across, weighing several pounds.

Prospects for continued excavation and search are promising, and Mr. Gidley with his corps of preparators are anxiously awaiting the time when the missing pieces of their great puzzle may be found and put in place.

Testing Insulating Materials

THE results of experiments indicates that the larger the surface of the plate electrode the smaller is the break down voltage in testing thin layers of insulation, the explanation being that thin layers have weak spots, which are more likely to be found by using large electrodes. An objection to the method is the possibility of air between the electrode and insulator,

New Aerodynamical Researches

Results of Many Important Experiments

By Gustave Eiffel

GUSTAVE EIFFEL'S new volume of researches, which is reviewed in a recent issue of *L'Aérophile*, is complete in itself, for it contains the most important of the results previously published, in addition to the results of more recent researches and a complete description of Eiffel's laboratory at Auteuil.

Among the new instruments is a telescope with a reticle of numerous cross-wires (Fig 1). Two selected points of the model are brought into coincidence with a wire when the air current is blowing and also when it is shut off. The angle through which the reticle is turned measures the deformation and the resultant change in incidence produced by a strong current.

For the proper centering of aeroplanes it is very important to know the direction and the point of application of the total resultant air pressure for different angles of incidence. From experiments with small models mounted on axes about which they could oscillate, Eiffel concludes that an aeroplane is stable if the resultant moves forward, and instable if the resultant moves backward, as the incidence is diminished.

The resultant air pressure on a sphere is proportional to the square of the diameter and the square of the velocity of the air current, if that velocity exceeds a certain value which increases with the diameter of the sphere. With smaller velocities the pressure is variable and much greater than would be given by this rule.

A cylinder of length equal to its diameter and with its axis perpendicular to the air current behaves like a sphere, in respect to a critical velocity, increasing with the diameter. Cylinders with plane ends oppose, to air currents parallel to their axes, four times as much resistance as similar cylinders with hemispherical ends.

Experiments with wires from 1.0 to 2.5 millimeters in diameter, stretched perpendicular to currents of velocities between 4 and 30 meters per second, showed that the resistance is nearly proportional to the diameter and the square of velocity. Wires 2.5 millimeters in diameter showed a resistance of 14.6 grammes per meter for a velocity of 10 meters per second. Hence, the 100 meters of similar wire in a Maurice Farman biplane, flying 20 meters per second, contribute nearly 6 kilogrammes, or about 4 per cent, to the total resistance to be overcome. The resistance of wires inclined

Fig. 2.—Horizontal sections of frame uprights.

to the wind is much smaller, and is reduced to one fifth the normal amount when the angle between the wire and the current is diminished to 30 degrees. Similar results were obtained with wire cables of diameters of 1.7 to 3.7 millimeters. Hence, as the air resistance increases with the diameter and strength with the square of the diameter, one large cable is preferable to two small ones.

Aeroplane uprights of the sectional forms shown in Fig. 2 showed resistances increasing less rapidly than the square of the velocity. This effect was greatest with the unsymmetrical forms, especially No. 2, which, at the velocities employed in aviation and with its blunt edge opposed to the current, showed only one fifth the resistance experienced by the symmetrical form, No. 3. At 25 meters per second the resistance of No. 2, with dimensions in the ratio of 1 to 3, is only one ninth that of a cylinder of a diameter equal to the greatest thickness of No. 2.

With the form No. 1, No. 2, or No. 3, respectively, the 60 meters of uprights in a Maurice Farman biplane, flying 20 meters per second, would experience a resistance of 5.6, 4.8, or 27.8 kilogrammes, equal to 3.7, 3.2, or 18.5 per cent of the resistance of the entire machine (150 kilogrammes).

Experiments were made with cylindrical hydroplane bodies having rounded and pointed ends, of the forms shown in Fig. 3. Forms I, II, and III differ only at the bow, II and V at the stern, I and IV in the length of the cylindrical part. The ratio of resistance to sec-

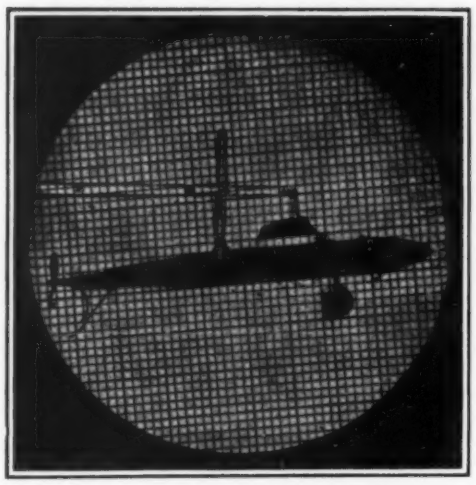


Fig. 1.—Reticle of observing telescope.

tional area is least for IV, and increases in the order IV. I, II, V, III, and V reversed, with the sharp point in front.

For airship bodies, as the buoyancy is proportional to the volume, the resistance should be referred to the two thirds power of the volume, instead of the sectional area. In this case II is the best form, and IV is the worst. The resistance of V is increased 16 per cent in the reversed position, with the point in front.

The researches on aeroplane wings of various forms have been continued. The Constantin concave edge (Fig. 4) is found advantageous to a degree proportional to the thickness of the wing. The Howard

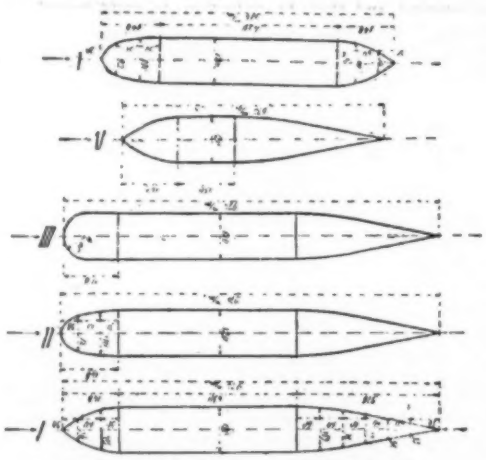


Fig. 3. Hydroplane or airship bodies.

Wright wing with two or three maxima of thickness attains, in part, its avowed objects, great strength and uniform pressure. Comparative tests of wings of different thickness but otherwise similar showed that, for a given curvature, a thin wing is better than a thick one. In regard to shape, decrease of the transverse dimension, relatively to the fore-and-aft dimension of the wing, was found to diminish the vertical and increase the horizontal air pressure.

The best ratio of dimensions seems to be about 6 to 1, but it varies with the incidence of the wind and the curvature of the wing. If the curvature is reduced to 1/30, for example, the ratio of dimensions may be reduced to 5 to 1. Researches on the effect of the lateral edges indicate that a trapezoidal wing, with its longest side behind, is preferable to a rectangular wing.

In experiments on the mutual interference of surfaces it was found that the deflection of the air downward by the front wings of a tandem monoplane diminishes the effective incidence of the rear wings and correspondingly diminishes their sustaining power, sometimes by 80 per cent. The incidence may even become negative, so that a downward pressure is exerted on the rear wings. The lifting power of the lower plane of a biplane is diminished about one third by the influence of the upper plane. The front wings of tandem monoplanes and the upper planes of biplanes, on the other hand, are not appreciably affected.

The chapter on aeroplanes contains a complete study of seventeen types in actual use, based on experiments with small models. For the monoplanes, the load was found to vary from 25 to 35 kilogrammes per square meter, the maximum speed from 95 to 120 kilometers per hour, the economical speed from 70 to 90 kilometers per hour, the minimum effective power from 5 to 6 horse-power per 100 kilogrammes. Allowing for ascent, we may estimate the necessary effective power per 100 kilogrammes at 8 horse-power, which would require 11 horse-power to be delivered by the motor to a propeller having an efficiency of 70 per cent.

For the biplanes the load varies from 15 to 30 kilogrammes per square meter of wing surface, and the effective power from 4 to 5 horse-power per 100 kilogrammes.

Experiments were made with five types of landing wheel. The spokes of one wheel were covered with canvas, which diminished the resistance one half. The importance of this improvement is evident when we consider that the four wheel of a Farman biplane, running 25 meters per second, offer a resistance of 7.6 kilogrammes if bare, and only 3.7 kilogrammes if covered. The difference is sufficient to allow the load to be increased 25 kilogrammes, the weight of 35 liters of gasoline. The canvas also prevents the wheel becoming entangled in grass.

Skids of three types were tested, with the following results, at 100 kilometers per hour. The Fabre skid experienced an upward pressure of 58.5 kilogrammes, thus supporting more than half its weight, 105 kilogrammes. The unsupported weight and the horizontal resistance, 9.5 kilogrammes, are slightly greater than those of the ordinary four-wheeled landing bogey. The

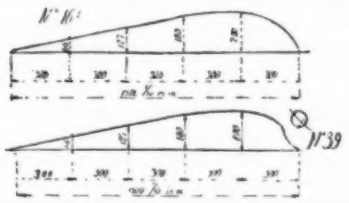


Fig. 4.—Convex and concave edge of wing.

Tellier skid, weighing 55 kilogrammes, shows an upward pressure of 11.3 kilogrammes and a horizontal resistance of 5.9 kilogrammes. The Breguet skid, weighing 70 kilogrammes, shows an upward pressure of 26 kilogrammes and a horizontal resistance of 10 kilogrammes.

The experiments with dirigibles were devoted to the distribution of external pressure on the gas bag, and the total resistance to progression experienced by detached gas bags and complete airships. The pressures were measured by means of a system of tubes, opening at the surface of the bag and connected with a manometer (Fig. 8). In the model of the "Clément-Bayard" the external pressure was found to be negative, except at the bow. Of the total resistance to progression, 44.5 per cent is due to the gas bag. The "Fleurus" model showed a similar distribution of pressure, but the gas bag contributed only 27 per cent of the resistance to progression. The close agreement between the resistance of the model and that of the "Fleurus" airship itself (which is accurately known) furnishes a verification, hitherto lacking, of the law of similitude for greatly differing dimensions. The model of the "Astra-Torrès" showed the same distribution of pressure, the gas bag contributing 34 per cent of the total resistance to progression.

Eiffel's projected researches on the resistance of buildings to the wind are inaugurated by experiments

Fig. 5.—Fabre skid.

Fig. 6.—Tellier skid.

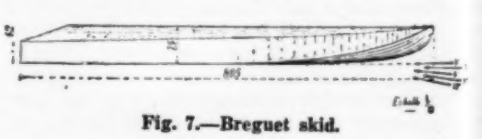


Fig. 7.—Breguet skid.

with models of sheds for dirigibles. In these, as in earlier experiments, it was found that wind, unlike a solid projection, produces little effect by its momentum, but acts chiefly by suction, or reduction of pressure, on all parts of the building which the wind does not strike directly. The maximum suction is produced at the peak of the roof. This explains the often observed instances of roofs lifted and carried away by the wind. An opening at any point of a building tends to equalize the external and internal pressure at that point, more or less rapidly, according to the size of the opening. Eiffel finds that a shed with an open lantern, or cupola, is safer than a completely closed shed, which, in turn, is safer than a shed with open gables.

The chapter on screw propellers contains the results of experiments with twenty-six models, some furnished

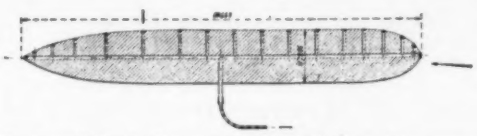


Fig. 8.—Method of measuring distribution of pressure on gas bags.

by constructors, others systematically designed to show the effects of pitch, thickness, and number of blades.

The deformation of thin blades tends to increase the pitch as the velocity of rotation increases, and this increase in pitch increases the deformation. A four-bladed propeller composed of two two-bladed propellers fastened together with their blades at right angles to each other was found nearly as efficient as the two two-bladed propellers mounted separately.

The results of the experiments and the properties of the various propellers are illustrated by novel and ingenious graphical methods, which furnish diagrams of remarkable convenience for practical application.

The volume, containing 400 pages and 267 illustrations, is accompanied by an atlas containing 29 plates, and numerical tables of the results of more than 4,000 experiments.

The reviewer quotes an opinion expressed last summer by Prof. Prandtl of Goettingen, director of the principal aerodynamical laboratory of Germany, to the effect that, of all the aerodynamical laboratories of the world, the Auteuil laboratory has rendered the most extensive and the most valuable service to aviation.

Preparing a diver for a descent

Dynamiting a Derelict

Removing a Wreck on the Great Lakes from the Course of Navigation

In attempting to force its way through heavy ice in Lake Michigan, off the harbor of Chicago, last winter the passenger and freight steamer "Iowa" was cut down and sunk in 36 feet of water. As the wreck formed a dangerous obstacle to navigation, a contract was made with a local company to remove it, and this was done by breaking up the hull with dynamite and removing the pieces.

The vessel was 202 feet long, 36 feet wide and 13 feet draft, of a gross tonnage of 1,157, and the divers found that it had rolled over and was lying bottom up, so that but a small portion of her cargo could be economicaly recovered, and the quickest way to remove the hull was to break it up. Divers were sent down, who placed a line of 2 by 4 scantling on each side of the keel for the full length of the boat and about a foot from the keel, thus forming two troughs in which to support the dynamite. The explosive was packed in sacks, 50 pounds being placed in each, and a sack was located every 20 feet from each side of the keel and alternated, making a sack for every 10 feet. Wires were led from primers in each sack to floats at the surface, and these were connected by lead wires with a battery carried in the firing boat, 500 yards away. A total of 250 pounds of explosive was used in this way, and an additional amount of 250 pounds was required to break up the stem piece and bow.

No sand bags nor other packing was used, and the column of water thrown up by the explosive rose to a height of fully 200 feet and disturbed an area of about 400 feet radius. It required forty days to completely break up and remove this wreck, including such salving work as was done.

One of the illustrations on this page shows a diver having his helmet adjusted preparatory to going below, and the other shows the explosion that broke up the wreck. The cover illustration shows how divers sometimes go overboard, but this flying leap can only be safely resorted to where the water is deep and there are no loose obstructions.

Manufacture of Coal-Tar "Crudes"

The chief processes employed in transforming the 10 coal-tar "crudes" into nearly 300 intermediates required for the direct production of dyestuffs are eleven in number. Slightly varied in individual cases, they constitute the great bulk of the operations performed in color works. They are of such fundamental importance that a brief description is desirable in order to bring out clearly the high degree of correlation and co-ordination that characterizes the industry. These processes are (1) nitration, (2) chlorination, (3) sulphonation, (4) reduction, (5) oxidation, (6) caustic fusion, (7) alkylation, (8) liming, (9) condensation, (10) carboxylation, (11) diazotizing and coupling.

(1) *Nitration.*—An aromatic compound is treated with a mixture of nitric acid and sulphuric acid. As a result usually one, but sometimes two or three, atoms of hydrogen are replaced by the nitro group, NO_2. The extent and nature of the reaction are largely effected by the factors of time, temperature and proportions. Usually the residual, somewhat diluted, sulphuric acid can be concentrated and used repeatedly.

(2) *Chlorination.*—Action of dry chlorine gas. The gas is usually obtained in connection with the electrolytic production of caustic soda from salt, is liquefied for transportation, and allowed to volatilize as needed. The reaction is not so easily controlled as nitration and a variety of substitution products are often the result, causing much difficulty in separation. One half of the chlorine employed is recovered in the form of hydrochloric acid. The synthetic production of indigo involves the use annually of over 5,000 tons of chlorine, prepared simultaneously with nearly 6,000 tons of caustic soda, and yielding, as by-product, nearly 8,000 tons of 33 per cent hydrochloric acid.

(3) *Sulphonation.*—The action of fuming sulphuric acid, usually in very large excess, to act as a vehicle. The reaction is, in a few cases, easily controlled. In most instances a variety of sulpho-acids are obtained, requiring separation, and involving the problem of utilization. The excess of sulphuric acid is generally lost.

(4) *Reduction.*—The substitution of hydrogen for oxygen in nitro-compounds, forming the corresponding amido-bodies. Thus, benzol is changed by nitration to nitrobenzol and that, by reduction, to amidobenzol, or aniline. Iron filings or turnings, with acetic or sulphuric acid, form the usual reducing agents. The resultant iron salts are without value.

(5) *Oxidation.*—Potassium bichromate, potassium chlorate, lead peroxide, manganese dioxide or a permanganate, with hydrochloric acid or sulphuric acid, are the usual reagents. The residues, chrome alum, potassium chloride, etc., are all susceptible of utilization.

(6) *Caustic Fusion.*—The operation is performed chiefly with sulpho-acids. As a result the sulpho-group is replaced by hydroxyl. Thus benzol monosulpho-acid, on fusion with caustic soda, gives phenol, or carbolic acid. The residue of sodium sulphite is sometimes used in making bisulphite, more often discarded. The operation is one requiring unusual care, and the results are often variable.

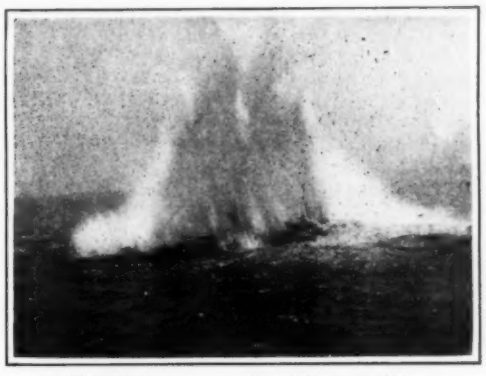
(7) *Alkylation.*—The introduction into hydroxyl or amido groups of the radicals methyl or ethyl, present in wood alcohol and grain alcohol. The alcohols, or methyl or ethyl chloride, are used, along with hydrochloric acid, and the operation is effected at elevated temperatures under pressure in autoclaves.

(8) *Liming.*—The use of lime or chalk to effect separations in mixtures, especially of sulpho-acids, through the differing solubilities of the calcium salts. Sometimes the purpose is to decompose chlorides and effect the separation of resultant acids and aldehydes.

(9) *Condensation.*—A large class of operations in which two molecules of the same substance, or of different substances, unite to form a new compound, with the elimination of water, or ammonia, or hydrochloric acid. Sulphuric acid in considerable excess is the usual condensing agent. When used it reappears as a spent acid, too weak to admit of profitable recovery. Other condensers are the chlorides of zinc, aluminium, antimony, sulphur and phosphorus. In most cases they can be recovered at slight cost and used repeatedly.

(10) *Carboxylation.*—The introduction of the acid carboxyl group, by the joint action of caustic soda and carbon dioxide on phenol and its homologues. Thus phenol gives salicylic acid; a-naphthol gives oxy-naphthoic acid. The alkali is recovered in the form of chloride or sulphate.

(11) *Diazotizing and Coupling.*—An aromatic amine reacts with nitrous acid, forming a diazo-compound. Thus aniline yields diazo-benzol. Such a diazo-compound in the presence usually of sodium acetate unites readily with a variety of aromatic substances; the operation is termed coupling. The product of such a reaction splits up, yielding the original amine and the amido-derivative of the second substance employed. Thus, salicylic acid, by coupling with a diazo-compound and subsequent reduction, is changed into amido-salicylic acid, an intermediate of widespread use. This sequence of reactions is of prime importance. It serves to produce a variety of intermediates, and is the fundamental operation in the manufacture of the so-called azo dyes, which constitute about one half of the number of artificial dyes now current in the world's trade.



Blowing up a wreck with dynamite

The purely chemical transformations fail to reveal the full extent of the sequence of operations in eventually obtaining intermediates from crudes by a chain of reactions. Between any two successive chemical changes there are from one to three mechanical operations, such as baking, boiling, filtering, precipitating, blowing off with steam, and the like. There are also minor chemical operations, such as the change of acids or bases into salts; the separation of salts from liquids; their purification, drying, and storing, etc.

In the preparation of about 300 intermediates by the use of these eleven classes of reactions there is encountered the greatest diversity of problems to be handled. Every step involves the production of compounds other than the one mainly sought. How to limit their appearance so far as possible, how to utilize them when inevitably formed, how to adjust and balance the consumption of all the products, are problems that demand exceptional technical and business ability and the closest co-operation between the manufacturing and the commercial staffs of an organization.—*Report of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.*

Chemical Changes in Geotropism

It has been known for some time that, when a root or a stem is subjected to geotropic stimulation—that is, when it is placed horizontally, and is receiving the gravity stimulus to which it responds after a time by curving downward or upward—chemical changes take place in the cells. Eva Schley (*Bot. Gazette*, Volume LVI) has investigated these changes in some detail, and obtained interesting results, using Broad Bean seedlings. In a growing shoot the acidity of the cell-sap is greatest at the tip, decreasing downward. When the shoot is geotropically stimulated, the concave side becomes at first more acid, but the acidity then diminishes until the greatest acidity is on the convex side. When visible curvature has been made the two sides again show equal acidity, and this condition remains until the tip has become vertical. These changes in acidity are not parallel with the relative rate of growth of the two sides; but that they are indicative of chemical processes—as yet not fully investigated—taking place in the cells as the result of geotropic stimulation is shown by the fact that the percentage of dry weight is always greater on the concave side. This is to be expected, since growth (involving loss of material) is greater on the convex side when a stem (or root) is curving under the stimulus of gravity.—*Knowledge.*

Munition Metals*

Some of the Numerous Materials Required for Military Purposes

In this article an attempt is made to compare briefly the resources of the Allies and the enemy countries in respect of metals which are regarded as essential for war purposes.

First in order of importance comes iron, the basis of the modern gun, armor-plate, armor-piercing projectile, shrapnel shell, high-explosive shell, and all the varieties of steel which find application in one way or another. Both sides have a sufficiency of iron ore and the accessories required for smelting, although the deposits in the enemy countries are inferior in quality to those possessed by the Allies. An illustration of this is furnished by a comparison of the amounts of acid and basic steel produced in Germany and Great Britain in 1913—the last year for which the complete figures are available. Germany's total steel production for that year was just under 19,000,000 tons, of which 96 per cent was made in basic-lined furnaces; Great Britain's output was 7,663,000 tons, of which only 36 per cent was made by the basic process. Both countries, however, imported considerable quantities of Swedish pig-iron, which is used for the manufacture of steels of the highest class, e. g., tool steels, and Great Britain also imported substantial amounts of Spanish hematite ore, which was smelted with the clay ironstone ores of the Cleveland district, which are low in iron, and contain, for the most part, more phosphorus than is compatible with the transformation of the resulting pig-iron into steel by any acid process.

The production of open-hearth steel from pig-iron—and such steel provides the casing of the high-explosive shell and the shrapnel shell—demands, however, a second and very important metal, namely, manganese, which in the form of ferro-manganese or silico-spiegel is used not only to de-oxidize the fluid steel, but to leave from 0.5 to 1.0 per cent manganese in the finished product. The chief producers of marketable manganese ore in order of importance are Russia, India, and the United States of America, which in 1913 furnished about 93 per cent of the total quantity mined. The raw material is pyrolusite, a "straight" manganese ore corresponding when pure to MnO_2. The main supplies of pure ores, therefore, are in the Allied or neutral countries. In 1913 Germany imported about 670,000 tons, chiefly from Russia. The figures of her domestic production in 1913 are not available, but in 1912 her output was 90,980 tons, while that of Austria-Hungary was 16,540 tons in 1913.

In spite of these figures there is no sufficient reason for concluding that the enemy countries will be greatly hampered even if all external sources of supply are shut off, as they probably are. Confining our attention to Germany, the predominant partner, it must be pointed out in the first place that 4,300,000 tons of her steel production in 1913 were exported, and that except in so far as Austria-Hungary and Turkey are concerned this excess would be available for her own munition needs if she could obtain sufficient manganese. In the second place, the last-named metal is relatively widespread and occurs in many minerals. It is only the limited demand and the abundant supply of high-grade ores to draw upon which have confined marketable ores to such products. The enemy countries will in all probability be able to supply their needs by mining lower grade ores within their own territories, and their metallurgists will no doubt have been able to make the requisite changes in the technology of steel manufacture to meet the altered conditions—quite apart from any stores of pure ore that may have been accumulated before the outbreak of war, and apart from any substitutes that may have been discovered.

The case of nickel, however, is very different. It is an indispensable constituent of gun and armor-plate steel, and of the modern bullet and armor-piercing projectile. In all these instances its action is specific, and it is doubtful whether any satisfactory substitute is known. It is therefore a munition metal of the highest importance. The world's production of nickel in 1912 was about 26,500 metric tons (a metric ton equals 2,204 pounds). Of this, Canadian mines and smelters produced 85 per cent in the form of a copper nickel matte (sulphide), 89 per cent of which was refined in the United States and the remainder at Clydach in South Wales, with the production of the pure metals. New Caledonia supplied almost all the remaining ore required, this being shipped to Europe and smelted there. Judged by Canadian standards the Norwegian production of nickel was very small, the output in 1912 being only about 400 tons.

The position, therefore, is that fully 98.5 per cent of the world's output of nickel ore was being produced in the Allied countries before the war broke out, and that the remainder was furnished by a neutral country. So far as Canada is concerned the situation was dominated by two companies, the International Nickel Company and the Mond Nickel Company, while the production of nickel ore in New Caledonia was monopolized by two large French companies. The only nickel ores situated in the enemy countries are kupfernickel ($NiAs$), cloanthite ($NiAs_2$), and nickel glance ($NiS_2 + NiAs_2$). Each of them can be worked for the production of nickel, but how inadequate a source of this metal they were may be judged from the imports of ore and metal into Germany in 1913. In the first six months she imported 6,643 metric tons of ore and 3,416 metric tons of metal. (It is to be noted, however, that her exports of the same metal were 2,409 tons in the same year.) The Norwegian nickel production may still be available for Germany, but this is nothing like enough for her requirements, and apart from pre-war stocks she will have to fall back on the above-mentioned native ores to furnish the requisite quantity of this metal.

Scarcely less important than nickel is the metal chromium, which, though it finds no application in the pure state, is an essential constituent of armor-plate, armor-piercing projectiles, and high-speed tool steels. Rhodesia and New Caledonia furnish between them the bulk of the principal chromium ore, chromite (an iron chromium oxide). Russia produces substantial amounts, while Greece and Asia Minor used to do so, though their output has diminished in recent years. It is more than likely that the requirements of the enemy countries are resulting in an increased output from the last-named countries, and it will be observed that even if Greece joins the Allies the Asia Minor supplies, which are sufficient, will still be open to the German and Austrian armament firms. Chromite is worked up into an alloy of iron and chromium (with or without carbon) known as ferro-chrome, and applied in this form to the production of the particular steel required.

All shells, whether shrapnel, high-explosive, or armor-piercing, are fitted with a copper band which serves a double purpose. It prevents contact between the shell and the gun-barrel, and, owing to its great ease of deformation under stress, accommodates itself to the very rapidly altering stresses set up in the tube after firing, making good contact with the rifling of the barrel, and thus preventing the rush of gas out of it in advance of the projectile. Before the war it was customary to use not pure copper, but an alloy containing a little zinc, as the material of the band, not because the zinc improved the properties of the copper, but because it was a cheaper metal, and a certain proportion of it could be used with only a slight sacrifice of ductility. Now that zinc has become much more expensive than copper there is no object in doing this. Copper is also the main constituent of cartridge brass and shell fuses, Admiralty gun metals, and high-tension hydraulic bronzes, so that from the point of view of both branches of the service it is a most important munition metal.

Of the normal annual world's output of copper—about one million tons—the United States of America produced 55 per cent in 1913. They are by far the greatest producers of this metal. Next came Japan with 7.3 per cent, followed closely by Spain and Portugal, Mexico, Australasia, Russia, and Chile, each of which supplied between 5 and 4 per cent. Of the Allies Italy furnished 0.16 per cent, Great Britain 0.03 per cent, while France was a non-producer. Of the enemy countries Germany's output was 2.5 per cent, and that of Austria-Hungary 0.4 per cent. None of the belligerent countries except Japan supplied its needs from internal sources in 1913; all of them except Japan imported copper from the United States of America; in that year Germany took 137,000 France 71,400, Italy 18,500, Austria-Hungary about 17,000, and Great Britain 15,000 tons.

The Allies are able to take delivery of such copper as they need, whereas the enemy countries have found it increasingly difficult to import this metal. The position probably is that they have succeeded in obtaining through neutral shipping and neutral countries more than is generally suspected, but nothing like enough for their war needs, more particularly since Italy joined the Allied countries. In 1913 it is estimated that Germany's consumption was 265,000, and Austria-Hungary's 50,000 tons; their united production was 29,400 tons. There is no means of estimating the war demand for this metal in these countries, to which, of course, Turkey must be added. It is quite certain, however, that its use is being rigorously restricted to purposes for which there is no substitute, and it is extremely probable that large stores were accumulated before the war. The very high price that Germany has recently been willing to pay for copper shows nevertheless that her reserves have been considerably depleted. Two things may be stated with confidence. The first is that all her copper mines, mills, and smelters are being worked to their utmost co-ordinated capacity, the second that her technical metallurgists will have endeavored to find a substitute for copper shell bands.

Aerial warfare has enthroned aluminium as *par excellence the* munition metal for this purpose, but its war usefulness is by no means confined to the construction of aircraft. One of the greatest metallurgical achievements of the last century was the adding of aluminium to the metals of every-day life. Thirty years ago the world's annual production was 5,500 pounds; in 1913 it was estimated to be 173,175,000 pounds. In this time it has risen from a rare metal to a yearly tonnage exceeded only by iron, lead, copper, zinc, and tin. To quote Prof. J. W. Richards ("Mineral Industry"): "It can confidently be anticipated that by the middle of this century it will rank next to, or even ahead of copper. It is already cheaper than tin, pound for pound, and cheaper than copper per unit of bulk or per unit of electrical conducting power, while the range of its applications and usefulness is extending more rapidly than that of lead or zinc."

One of the less well known uses of aluminium is as a constituent of the bursting charge for shells. "Ammonal" is an explosive the constituents of which are ammonium nitrate and finely divided aluminium. It is not a propellant explosive, such as cordite or other of the smokeless powders; its disruptive effect is too great, and its explosion too sudden. But this very fact renders it suitable as a bursting charge for shells, and Austria-Hungary is using it for filling the shells for the howitzer batteries. The United States and Canada produced nearly half the world's output of aluminium in 1913, the remainder being furnished in almost equal amounts by France, Great Britain, and Switzerland, leaving out of account a tonnage of 800 produced in Italy. So far as the Allies are concerned, therefore, they are in a much better position than the enemy countries with regard to the supply of this metal. Moreover, France contains the most suitable European deposits of the raw material of manufacture, viz., bauxite. The Swiss production is available for the enemy countries, and it is known that Germany has since the war become a producer of the metal.

Next there is zinc, the metal of which the selling price has appreciated to five times its pre-war figure. Originally only two-fifths the price of copper, it is now decidedly above it, in spite of a marked appreciation in the price of copper itself. The most important munition uses of zinc are as a constituent of cartridge brass and shell fuses, and as a covering for iron barbed-wire fencing. In 1913 the principal producers of the metal were the United States, Germany and Belgium; whereas, however, the first-named smelted domestic ores, the last two relied mainly on zinc concentrates imported from the Broken Hill mines in New South Wales, where, owing mainly to the high price of labor, it does not pay to smelt the ore locally, or even in the country. France, Spain, Great Britain also produce substantial amounts though not enough for their own needs. Although the importation of Australian ore into the enemy countries is now stopped, they have considerable supplies of local ore both in Silesia, Hungary, Carinthia, and Tyrol. Unfortunately for Great Britain her zinc-smelting furnaces are not well adapted for dealing with Broken Hill concentrates, and there are upward of 80,000 tons seized in enemy shipping which are lying idle in our yards in this country. She is in the unsatisfactory position of having to draw upon the United States for the bulk of her supplies. The shortage of domestic zinc is bound to continue unless works are built and operated which are capable of dealing with the zinc concentrates from Broken Hill. It is, therefore, of national importance so long as the war lasts that the use of zinc, whether as such or for alloys, should be restricted to purposes for which this metal is absolutely necessary.

Lead calls for only brief mention. Germany is a very large producer, and her output with that of Austria is sufficient for the requirements of the enemy countries. Australia is the largest producer among the Allies, who, however, do not furnish enough for their needs, and draw upon the United States, Spain, and Mexico. The shrapnel bullet is a lead-antimony alloy, the antimony producing the requisite hardening and embrittling effect. In spite of the fact that the shrapnel shell is much less

* H. C. H. Carpenter in *Nature*

suitable than the high-explosive shell for the offensive land operations of the present war, the price of antimony has appreciated almost as much as that of zinc. The normal annual world's production is less than 20,000 tons, of which China furnishes two thirds and France the bulk of the remainder. Before the war Hungary was producing about 800 tons per annum, but doubtless this amount could be substantially increased.

Tin as a constituent of tin-plate, the various anti-friction metals, solders, and Admiralty gun-metals, is a munition metal of no small importance, the world's normal annual output being about 120,000 tons. Of this the Federated Malay States produce about half from native ore, in addition to exporting ore which is smelted in various European countries; England comes next as a producer of the metal, although 75 per cent of her output is derived from imported ores; then follow Banca, Germany, Australia, Billiton, and China in the order mentioned. The enemy countries have hitherto relied on imported ores for raw material.

To sum up, the position may be stated broadly as follows: Of the ten munition metals, the chief sources of production and uses of which have been passed in review, the enemy countries can certainly produce five without having recourse to imports, viz., iron (the basis of the various steels used for war purposes), manganese, chromium, zinc, and lead; on the other hand, it is doubtful whether they can produce sufficient nickel, copper, aluminium, tin, and antimony from domestic ores. In view of the fact, however, that they prepared for this war with extreme care and foresight, it may safely be concluded that large stocks, either of ores or the corresponding metals, or both, will have been accumulated in those countries. However confident the Higher German Command may ostensibly have been of a rapid victory, they will quite certainly have laid their plans to wage a prolonged war if it should prove to be necessary, and such plans will have included the accumulation of munition ores and metals of which their countries produced an insufficient amount. There is accordingly no adequate reason for concluding that the enemy countries are likely—in spite of the prodigious scale upon which the war is being conducted—to run short of metals which are *essential* for war purposes for some time to come. Moreover, it may safely be concluded that their technical metallurgists will have been mobilized in the direction of discovering substitutes for any of the above metals of which a shortage is liable to occur in a long war.

The Allies for their part can produce from their own sources all the iron, manganese, nickel, chromium, tin, and most of the aluminium they require; their command of the seas enables them to obtain, principally from the United States, their deficiencies in aluminium, copper, and lead; China furnishes the requisite antimony. Zinc is the only important munition metal of which there is a shortage, in spite of the great speed with which the American furnaces are being operated. Wherever it is possible to substitute zinc by another metal it is of national importance that it should be done.

The Mushroom Lorelei and Its Dangers

By Riley M. Fletcher Berry

THOUSANDS of untrained people profess to know: to readily recognize one type of edible mushrooms, and this one only. Because of thus specializing they claim their "knowledge" to be infallible and themselves, therefore, safe from any danger in eating them; that it is only the man who experiments with many kinds of this fungus food who runs risks. But the "grain of knowledge" held by these thousands who could not, if they would, analyze and prove the safety of the signals they imagine they know, is so truly dangerous that in many cases they might better have taken a dose of poison before faring forth for mushrooms: "better" because they would thus have poisoned themselves *only*, and not their families, their neighbors and the strangers within their gates.

As a matter of fact, to be willing to admit the slightest danger in connection with mushrooms, the slightest possibility that one may make a mistake, comes, as a rule, only when, after perhaps years of exemption from accidents, such people have seriously made ill themselves or their friends through some of these fungi. (To be poisoned by others might seem sufficient, but seldom effects a cure because in such case it is "the other fellow" who is at fault.) And one who has really studied mushrooms always shudders when reading articles concerning their value as food, with recipes for preparation (no matter what the reputation of the writer), *unless* there is appended a clear code of *danger signals*.

The popular beliefs that there are differences between mushrooms and toadstools and simple tests by which one may recognize the "poisonous toadstools" are part of the Mushroom Lorelei's dangers, for "mushroom" and "toadstool" are synonymous terms—exactly the same thing—and the popular, so-called "tests" are valueless. For instance, the claim is frequently made that if, when a silver spoon is placed in a vessel in which mushrooms are cooking, the spoon discolors, the mushrooms are poisonous, and, conversely, if in such contact the spoon remains bright it proves the fungi edible. This is *not true*. When decomposition has set in, *any* mushroom (no matter how innocent originally) is liable to both discolor spoons and make the eater ill, and the deadliest of all poisonous mushrooms when freshly gathered will *not* discolor silver.

Neither is it true that if a mushroom have a pleasant odor or taste, or if the stem be solid or the skin readily peeled from the flesh (as many people claim), it is edible. And just as valueless is the "test" of (supposed) change of color when poisonous mushrooms are placed in salt water or sprinkled with salt, for the deadly Amanita will be unaffected by either. (Any possibly poisonous principle is rendered less active by soaking in salt water, *if the liquor is not used*, but it is merely a safeguard and not a "test.") Also, while the color of the under side of the common meadow mushroom (the one "everyone" claims to know) is a help, this alone should not be relied upon, as there are other pink-gilled mushrooms which may or may not be edible. Not even Nero's cooks, when given his carefully selected mushrooms to prepare for certain infamously fatal feasts, could have discovered and given warning of their deadly nature with *all* these reputed, popular "tests" used. Sometimes spore-prints alone (as in the case of a mushroom which closely resembles the edible, familiar, oyster mushroom, but which scientists yet believe to be usually injurious and therefore rank it as very doubtful), will determine whether or not a toadstool may be safely eaten, and there are comparatively few who either know how to avoid danger by this process or would think it necessary to take the time for it.

One ever-present danger is the possible mixing of poisonous with edible mushrooms. These sometimes grow side by side, with a superficial resemblance, and even after a basketful has been taken home and sorted, should it be discovered that a mistake has been made and poisonous ones removed, it will not necessarily secure exemption from illness to the eaters, since poison is very frequently absorbed from close contact with non-edible ones by those originally quite edible. This degree of poisoning may not happen to be fatal, but the really serious danger in such mixtures is that the great preponderance of edible mushrooms is very likely indeed to cause the few poisonous ones present to go unobserved and do deadly damage. It is possible for one to absord a sickening degree of poison from non-edible mushrooms from merely handling them and even the odor alone has been known to cause a most unpleasant illness.

The "Shaggy-maned Mushroom" (*Coprinus comatus*), its relative the "Inky Toadstool" (*Coprinus atramantarius*) and the "Fairy Ring Mushroom" (*Marasmius oreades*), with certain of the Boleti; members of the Russula group; Morels and other familiar types of mushrooms are supposedly safely distinguishable and are often recommended as edible to the public at large, but, hidden in closets, all of them have many skeletons to prove the danger of their delights; "strange" cases of confusing them with *poisonous mushrooms which bear close resemblance*.

It is an illuminating fact, however, that it is through the sorcery of the common Meadow Mushroom (*Agaricus campestris*), concerning which so many profess infallible knowledge, and whose familiar, friendly face and rose-hued parasol seem always to signal safety, that most mushroom victims have been lured upon bewitchingly concealed but fatal rocks. One may have been fortunate for years in recognizing and gathering the mature mushroom of this type and then make a fatal mistake with it in the "button" stage, for in this immature condition it is very difficult to discriminate between edible and poisonous mushrooms in general. Indeed, the most deadly Amanita seldom distinctly reveals its poison cup (upon which mycologists partly rely in identifying it) in its button stage. Its danger is increased by the fact that several of the Amanita group prove the exception by being edible. And the slow action of its poison is one of the deadliest things about the deadly Amanita, for by the time the presence of the toxin is revealed (possibly not till eight hours after it enters the system) it is difficult to counteract it although atropine is now known to be antidote for it.

There is but one form of mushroom which can be safely recommended to the world at large, to the unthinking who recognize no danger, the puff-ball. And even this should not be gathered at either extreme of its existence, since in its button stage it may be confounded with the Amanita and when beyond maturity it may be infested with maggots too tiny to notice until they have made the eater ill.

The lure of the mushroom is so difficult to resist that it should be repeated that there is *no* absolutely safe, general or single, popular test which can be applied to mushrooms growing wild, although the presence of the poison-cup in the Amanita group is a help. Yet even here care must be taken in digging around the stalk that the cup is not accidentally broken off and unwittingly left in the ground. The best thing to do is to grow one's own mushrooms and to read and study under practical direction not only government bulletins but the several valuable books on mushrooms which have been published in this country. All of these contain facts which will act as deterrents, *if one will heed them*. It is true that one may not heed warnings and yet possibly live after eating poisonous mushrooms if one soaks them lengthily in brine or vinegar and pours this off before cooking. This, however, destroys the delicate flavor of the mushroom which makes it the coveted morsel centuries of epicures have declared it to be.

If, however, you value flavor more than life and have carelessly relied upon mere popular "tests," eat them and run the risk of very quickly taking the road which led Claudius of Rome, Alexis of Russia and so many other less famous mushroom-lovers, beyond this earth. But if you value life more than flavor and prefer the lesser of two risks, then by all means destroy flavor rather than yourself. If you are wise, however, you will take *no risks at all*, you will either make as serious a study of mushrooms before relying upon your own inexperience or that of your neighbor (even if he profess to have had acquaintance with the "real mushroom" from cradle-days) as you would of swimming before venturing into deep water; or you will take the word of a trained mycologist *only*, or you will avoid mushrooms of the wild type entirely, IF YOU ARE WISE.

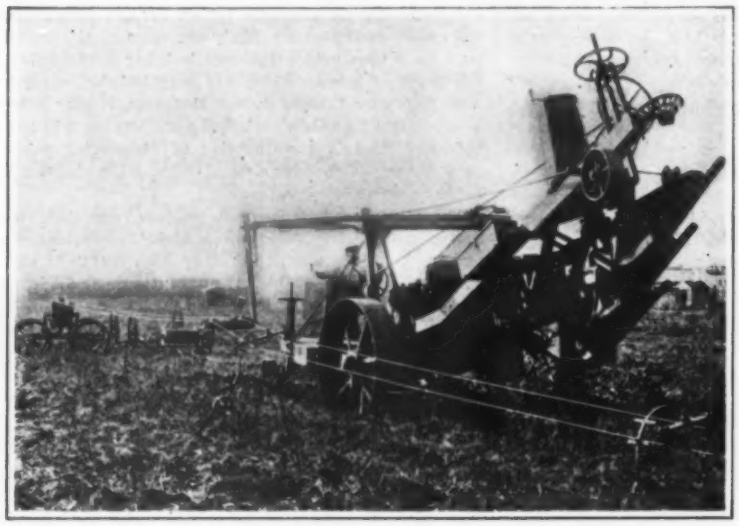
Electrical Precipitation of Suspended Matter

THE dispersal of fog by electrical precipitation is theoretically possible, and perhaps it may be developed to a practical state that will render navigation safe in harbors and other dangerous places when fogs are thick. It was known as early as 1824 that finely divided particles carried in suspension in the air could be deposited on a plate by means of the brush discharge from a static machine. No practical progress was made, however, owing to the fact that the static machines then available were entirely inadequate for any commercial application. In 1850 the same phenomenon was reported in the *Mechanics Magazine* of London, and attention was called to the fact that it provided a means of throwing down finely divided particles carried in suspension in the air. In 1884, Sir Oliver Lodge, without knowledge of previous discoveries, reported before a meeting of the British Society of Chemical Industry his discovery of this phenomenon, and patents upon the general principle were taken out at that time in Great Britain and several other countries. In 1905 Prof. Cottrell, then connected with the University of California, took up the work. He instituted the high-potential direct current for the static machine formerly employed, and arranged to tap off the peak of the voltage wave from a high-potential alternating-current circuit, thus securing a high-potential unidirectional source of energy. This permitted the practical application of the process to sulphuric acid plants, powder works, cement plants and smelters. At Riverside, Cal., ninety tons of cement dust per day are recovered from the flues of the Riverside Portland Cement Works by this process, with a power expenditure of only 35 kilowatts.

The theory of the process is that the solid conducting particles in suspension become charged in passing through the intense static field formed by a voltage of from 30,000 to 60,000 volts. These particles are driven away from the field of greatest intensity by the interaction between the charge and the static field. Other solid particles are also driven out, doubtless by collision with the charged particles. A recent application of the principle is the removal of tar from producer gas which is to be used in a gas engine. A recent installation for this purpose has been made at the plant of the Ford Motor Co., Detroit, Mich. In passing the gas through an intense static field, the particles of tar become ionized and intense molecular activity results. The fine particles of tar vapor collide and form into large globules, which are then easily removed by mechanical filtration. Electrical precipitation has been experimented with as a means of solving the smoke problem, but it has not been so successful along these lines as it has been in the commercial applications which involve the removal of fumes and dust.—*Machinery*.

Dissipating Fog by Electricity

A RECENT statement in the daily press is to the effect that a large transformer, capable of producing 1,000,000 volts current, has been constructed at San Francisco for experiments in dissipating fog by powerful electric discharges, and the results are awaited with interest by shipping people. Another method of clearing up fog is by spreading an oil film on the water.



A large gang plow operated by electricity.

Threshing in the wheat field by electric power.

Electricity in Agriculture—I*

Advantages That Make It a Necessity on a Modern Farm

By Carl J. Rohrer, Agricultural Specialist of the General Electric Company

FIFTEEN years ago an electric installation on a farm was a rarity, ten years ago it was still thought to be a great novelty, and not until about five years later did the farmer begin to seriously consider the many advantages of electricity. Since that time, however, the farmer's change in attitude has been rapid and to-day he is an enthusiastic advocate of electric light and power. Almost every farmer who is not using electricity at the present time is laying plans to do so as soon as his financial condition permits. This is conclusively proven by the fact that our various agricultural colleges are being flooded with inquiries on this subject. So heavy has the pressure become that classes are being organized and bulletins prepared.

This rapid change is really to be considered remarkable when one stops to reflect that our present population is only about 31 persons per square mile and that only about 50 per cent of these live in the rural districts.

In Europe, especially in Germany, the electrification of the farm has reached a very pronounced stage of development. However, Europe's population is so much greater per square mile that one would naturally expect them to lead in this particular line. Austria-Hungary has a population of 196 per square mile, France 191, Germany 312 and Italy 313. All of these countries have from six to ten times our population per unit area and agriculture is practised in its most intensive state. There very exhaustive studies have been made as to the possibility of agricultural electrical development. Numerous exhibits have been held to educate the rural population and every government has established experiment stations where new farm apparatus of all kinds has been tested and tried out under the supervision of competent government officials. If found wanting the facts are so given and the machine is not recommended, with the consequent result that only suitable apparatus is purchased by the farmer.

A large number of small central stations have been established in the rural districts of Germany supplying light and power to a few small towns and the rural population of the vicinity. Many of the German farmers carry on other industries in connection with their farm work because it enables them to keep their help busy when work is slack or the weather unfavorable for labor in the field. This is a type of intensive agriculture which is rarely practised in this country.

In Europe many of the farm machines are supplied by their manufacturers equipped with suitable electric motors. Feed grinders and ensilage cutters with direct connected motors are just as common in Germany as motor-driven lathes and planers in the United States.

Perhaps the most advanced step made by Europe has been in the way of electric plowing. France, Germany and Italy all have made a very large number of experiments to determine the adaptability of electricity for plowing, and such outfits have been put in actual production by European manufacturers. Germany has a considerable number of such plowing equipments in actual operation.

Two systems of electric plowing are in common use. In both systems the general appearance of the plow is the same, it being constructed in such a way as to enable it to operate while traveling in either direction.

In one the current is supplied to the plow by means of a two-conductor trolley. A heavy chain is stretched across the field and securely anchored at each end. This chain passes around a drum mounted on the plow,

An electrically-operated drainage pump.

the drum in turn being driven by the electric motor. The anchor wagons to which the chain is attached at each end of the field automatically move forward as the plow travels back and forth across the field.

The other system requires two large trucks, one at each end of the field, upon each of which are mounted an electric motor and cable drum. The plow is drawn back and forth by means of a cable attached to each end of the plow and to the drums. This equipment, however, is more expensive to operate as it requires at least three men and a duplicate system of motors and winding drums.

An electric brooder.

A complete plowing equipment of the truck and cable type capable of drawing five or six 14-inch plows across a field 1,300 feet wide will cost in the neighborhood of $15,000. This outfit is complete in every detail and includes two 75 horse-power motors, transformers, switches, plows, cables and trucks. A complete equipment of the above capacity using a chain and trolley and one 75 horse-power motor will cost approximately $10,500.

Little or no experimentation has been made in this country to develop a suitable electrical plowing equipment, primarily because electrical transmission systems are not available and also because of the low cost of coal and fuel oils. A fortune awaits the man who will develop and put into practical operation an electrical plowing outfit which will be reasonable in first cost and economical in operation.

In 1905 the government of the Province of Ontario, Canada, created what is known as "The Hydro-Electric Commission." This commission was primarily appointed to develop, control and operate the water powers belonging to the Province. In 1911 the Provincial Legislature passed a law, the object of which was to enable the commission to distribute electrical energy to the residents of the rural districts. An extensive campaign of education was conducted consisting of meetings and exhibits throughout the Province.

In addition, a number of demonstration farms have been completely equipped. The result has been that a large number of farmers have signed power and lighting contracts; however, no definite figures are available as to the actual number of farmers signing such agreements.

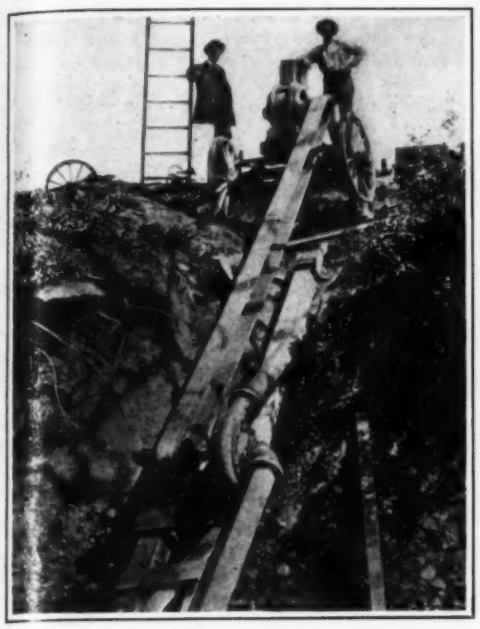
In the United States the application of electricity to the farm is advancing, as is shown by the enormous increase in the number of isolated plant manufacturers, there being about 200 of such companies at the present time. This coupled with the fact that central stations are supplying at present between 50,000 and 75,000 strictly rural customers gives some idea of the possibilities of rural development.

Electricity at the present time can be advantageously applied to over 125 various uses on the farm. Electric applications even in their simplest form bring great advantages to the farmer not only in economy but because they eliminate to a very large extent the drudgery of farm life.

The hard work and the long hours of work have made the farm labor problem a serious one. It is so serious in fact that many farmers instead of trying to get efficient labor have turned their farms over to tenants or else seeded their land to grass and pastured their stock. Electricity perhaps as much as any other one factor will tend to alleviate or minimize these conditions and make it easier to secure farm labor by checking the migration of our young men to the city. It will also make possible the more economical performance of farm operations by shortening the time required and lessening the cost, which will in turn enable the farmer to pay higher wages for shorter hours of work.

Perhaps the greatest progress in the rural field has been in the application of electric motors for irrigation

* Courtesy of the *General Electric Review*.



Irrigation pump operated by a portable motor.

and for the reclamation of land. In our western sections, irrigation is absolutely necessary in order to produce crops of any appreciable size and in many localities it is impossible for vegetation to exist without the artificial application of water.

The gravity system is perhaps the one most extensively used in the West; however, it has two serious disadvantages, namely, the inability of the farmer to get his quota of water any time he desires and also the impossibility of irrigating any land situated at a level higher than the canal itself. To overcome these difficulties suitable pumping equipments have been installed, the water being secured from underground supplies or from rivers, lakes and canals.

Steam, gasoline and distillate engines, as well as electric motors, have been installed by the thousand in this territory. The area under irrigation by pumping in 1909 amounted to 500,000 acres, the horse-power required being 243,500 horse-power. Conservative estimates show that these figures have been at least doubled since the taking of the 1910 census.

The United States Government and the various State agricultural experiment stations have spent thousands of dollars in experimental work to determine the proper amounts of water necessary for crops in the various sections of the country. The Government has also assisted in financing the great irrigation projects.

As in the case of all other farm operations, labor is scarce, and any mechanical device which will eliminate the necessity of such labor, unless such device is very expensive, will be welcomed with open arms by the farmer. While steam, gasoline and distillate engines as prime movers cut the labor cost to a considerable extent, they are in no way comparable to the saving brought about by the use of electric motors. In the arid regions, where a large amount of water is required, it is often necessary to operate pumping plants twenty-four hours a day for a month at a time and in many cases six months. The engine-driven plants require an operator to be in practically constant attendance, while in the case of the motor-driven plant a casual inspection every two or three days will suffice. This difference in the amount of attendance required means a considerable monetary saving in the course of a year.

The extended use of electrically driven irrigation plants is a comparatively new proposition, most of them having been installed in the last seven or eight years. Perhaps the greatest development has been made in California, where one company alone has approximately 9,000 farms using electric power.

This power company derives a gross income of approximately $500,000 per year from motor-driven irrigation plants. Several other companies in California have from 2,000 to 7,000 farmers on their lines. The amount of irrigation load has been such that even in the case of the very large companies, the peak load has been shifted from the evening hours of the winter months where it ordinarily comes to the daylight hours of the summer months.

The rural load of many of the smaller power companies consists of as much as 60 per cent of the total. One company especially has an ideal combination in the way of load, as it consists of railway, lighting and irrigation pumping with a yearly load factor of approximately 60 per cent. During the height of the irrigation season, the peak load comes on at about nine o'clock in the morning, with another peak almost as high at four o'clock in the afternoon. The minimum load is at 4 A. M., being approximately one third of the morning peak. This company's load factor during the summer months is approximately 70 per cent.

Another California central station has a rural load amounting to 33 per cent of the total, another 50 per cent, while in the case of a third it amounts to 67 per cent. The rural connected load in motors in California is at least 130,000 horse-power, most of this being for irrigation.

While California is the leading State as far as irrigation is concerned, Washington, Oregon, Colorado, New Mexico, Utah, and Arizona all have large numbers of farmers using electric motors. The States of Washington and Oregon alone have at least 5,000 horse-power in electric pumping motors.

This is in reality only a very small percentage of the prospective business, when one stops to realize that California has 88,000 farms, Arizona 9,000, New Mexico 35,000, Oregon 45,000, Utah 21,000, Colorado 46,000, and Washington 56,000 farms. Probably 50 to 75 per cent of these farms can use irrigation to advantage.

From these figures it can be readily seen that the field for irrigation is by no means exhausted and that the possibilities for irrigation load are still very great.

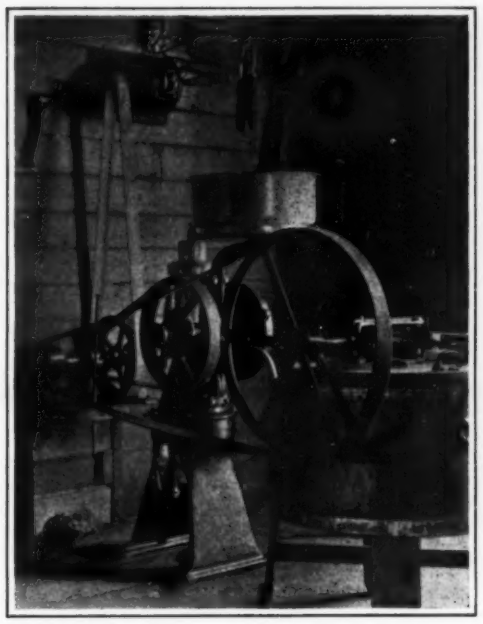
It is perhaps the common impression that irrigation is not usually practised except in our far western States; however, this is not the case. There are to be found a considerable number of reclamation projects in the South and in the Mississippi Valley, where motor-driven pumps are used, the apparatus being so arranged that water can be pumped in either direction. During the flood periods the water is pumped into the river or lake, while during the dry season the water is pumped from the river or lake back upon the land.

Rice irrigation is also of considerable importance, as the 1909 census shows that there were about 1,900 pumping plants in use in Arkansas, Louisiana, and Texas aggregating 118,000 horse-power and capable of delivering 9,500,000 gallons of water per minute. If these pumps operated twenty-four hours a day for one week, they would cover 270 square miles of land 2 inches deep.

There is also another field in the humid sections of the United States for the application of water by artificial methods, namely, the truck and market garden. In some sections of the East this has reached a very considerable stage of development.

It is a peculiar, but well established fact, that when irrigation is inaugurated in a truck or market garden region, the prices obtained by the farmers using such irrigation are so much greater that the other truck and market gardeners in that vicinity have been compelled to install irrigation or else accept lower prices for their produce. This is due to the greater quantity and better quality of the products obtained under irrigation, coupled with the irrigation farmer's ability to market his crops earlier, thus getting the cream of the market.

The United States Weather Bureau reports show that almost every summer there are considerable periods of time when a condition of drought exists, namely, less than one inch of rainfall in any fifteen-day period. These droughts sometimes last for a month or six weeks, completely exhausting the supply of moisture in the soil and causing a decided shrinkage in the quantity and



An electrically-driven cream separator and churn.

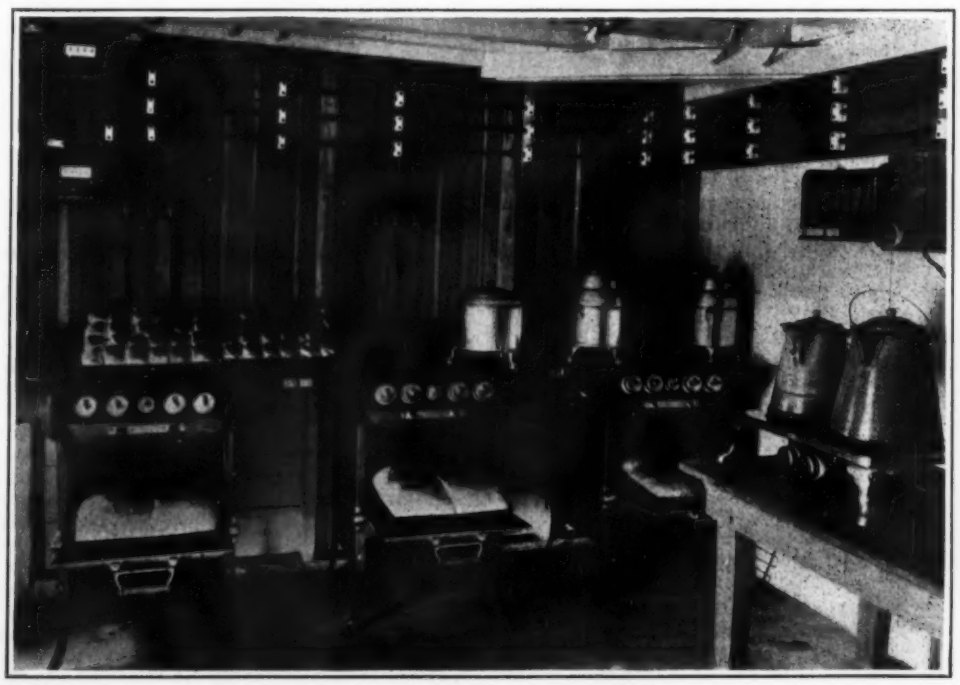
producing a very inferior quality of product, which must be sold at low prices.

The system of irrigation mainly used for supplying water in the humid sections is almost exclusively of the overhead type, or what is commonly known as the sprinkler system. By this method water is applied under considerable pressure in order to deliver it to the plants in the form of a fine spray. The pressure ordinarily used is from 40 to 50 pounds per square inch at the nozzles; this means that a large amount of energy will be required to drive the pump, as it must work against a head of from 90 to 115 feet plus the vertical elevation of the pipes above the level of the water in the well together with the friction loss in the pipes themselves.

Motors for this kind of irrigation are not usually run continuously, ordinarily they are installed in such capacities that they will operate from three to eight hours per day, depending on the amount of rainfall. One to one and one half inches of water per week is ordinarily considered sufficient to grow good crops; if the rainfall drops below this the additional water is supplied by irrigation. Unless the season is very wet, the plants are usually sprinkled for a short period once a day—either in the early morning or late in the evening—as this has been found to materially aid their growth.

The use of this type of irrigation equipment requires a considerable outlay of money, the piping, pumping equipment, etc., making the installation cost from $100 to $150 per acre.

The results obtained, however, have been very satisfactory, and the increase in the quantity and quality of product has made it a paying proposition even when the additional cost of such systems has been considered.



Cooking by electricity in a large ranch kitchen.

There is a large amount of land in the vicinity of all our large cities devoted to the raising of such crops, and in view of the severe competition in this particular phase of agriculture it will be absolutely necessary in the future for this class of farmers to install pumping equipments in order to successfully compete with those using irrigation. Already many of the more progressive market gardeners have taken advantage of the additional benefits derived and are using motors of from 5 to 25 horse-power to operate the necessary pumping equipments.

The load is ideal from a central station standpoint, in that it is exclusively a summer load and rarely, if ever, interferes with the lighting peak. Those companies who have such customers on their lines have found that this is very good business provided only short line extensions are required. If necessary to run long lines the business is not desirable unless the farmer consents to pay part of the first cost.

In the mind of the farmer, lighting is naturally the first consideration and, therefore, the conveniences derived from electric lights are of almost inestimable value from his standpoint. Ordinarily the farmer considers that the lighting of the house and the proper illumination of the barns is the first and of primary importance; however, after these lights have been installed and their value fully realized, the next step is usually the installation of a number of lamps around the farm lots, situated at such points as to give most satisfactory results.

Of principal importance, however, is the very material reduction of fire risk, great losses each year being caused by lamps and lanterns together with the habit of using matches as a source of momentary light.

The amount of work required of the farmer's wife is usually large, to say the least, and therefore any conveniences or labor-saving devices are of great assistance in performing the household duties. A good system of domestic water supply, saving hundreds of steps during the course of a day, is an example, for such a system with an electric motor drive and equipped with an automatic starting and stopping device requires practically no attention and pays for itself many times in the saving of actual labor.

It is really remarkable what can be accomplished in the average farm home with the aid of a small motor of ⅛ or ¼ horse-power capacity. In a large number of instances a motor has been installed at some convenient point in the kitchen or pantry and belted to a line shaft having a number of pulleys of various diameters. On a suitable base has been mounted a number of clamps convenient for holding the different machines used in the kitchen.

In one particular instance, this outfit consisted of a coffee grinder, flour sifter, meat grinder, bread mixer, egg beater, and buffer and grinder. Furthermore, the motor was mounted in such a manner that it could be easily removed and used to operate the washing machine, churn and sewing machine.

For instance, the washing machine was located in the basement, the churning was done on the back porch in summer and in the kitchen in the winter, while the sewing machine was equipped with clamps for holding the motor. In the case of the washing machine, the wringer was also arranged to enable it to be operated by power.

All the necessary equipment for transmitting the power was designed and installed by the farmer himself. The whole outfit took very little room and represented a comparatively small initial investment. This particular instance is not an isolated case, as investigation will show that there are hundreds of such installations, perhaps not quite so complete as to details, but still serving the need of a definite case.

Electric vacuum cleaners which can be operated from the lighting circuit are also in considerable demand, as they are great labor savers and easily transportable from one room to the other.

An electric fan in the kitchen on a hot summer's day is a piece of electrical equipment which is very much appreciated by the housewife.

Of the heating devices, the electric iron is almost in universal use wherever electricity is available, especially during the summer months, as it enables the housewife to do her ironing in the coolest and most convenient place. The various other heating devices are not so popular, although there are a considerable number of heating pads, hot water heaters, toasters, hot plates and coffee percolators in use.

(To be continued.)

Making Good Photographs*

Practical Suggestions for Producing Useful Pictures

CAMERAS are so common that it is generally assumed that everyone knows how to make pictures. That this is far from the case the average photograph is examined with a view to reproduction for illustrative purposes. In view of this fact, and the ever increasing practical use of photographs, the following instructions, issued by the Division Publications of the United States Department of Agriculture, is well worth the consideration of every user of a camera.

An unnecessarily large number of the pictures submitted for development have been improperly made. Sometimes the exposure has been under or over timed, the focus or diaphragm may have been improperly set, the light may have been impossible, or the subject unsuited to the capacity of the particular camera employed. To obviate these dangers, those who are not skilled in photography should use as simple a camera as possible. Except in expert hands, the more complicated the camera the more likely is the negative to be photographically defective. Special lenses involve problems of exact focusing and the proper setting of the diaphragm with relation to distance, light, and time, which, in the majority of cases, need not be considered with a good but simple lens so set as to operate effectively with a universal focus. Certain technical results can, of course, be obtained only by the use of special equipment, but in any event such work usually requires the services of an expert photographer.

Another common source of failure is the attempt to take a slow exposure without making certain that the camera box is absolutely steady. It is almost impossible to take a successful photograph with a longer exposure than one twenty-fifth of a second unless the camera is firmly fixed. Light folding tripods add little to the burden of luggage, but where it is absolutely impossible to carry one, an aluminium device which enables the photographer to fix the camera to the top of a chair, an empty barrel, or a fence rail, may be found useful for time exposures. This device consists of a screw clamp, an adjustable ball joint, and a screw. It weighs but a few ounces and can readily be carried in the pocket.

In order to assist field workers who are called upon to take photographs in the course of their work, a few simple directions which will aid those who have had comparatively little experience in the taking of pictures in obtaining more successful negatives are given below.

SIMPLE DIRECTIONS FOR PHOTOGRAPHY.

Size of Camera and Lens.—The best and most consistent work done by men in the field is with cameras 3¼ by 4¼ inches in size. The lens necessary to cover sharply this size of plate or film is of short enough focus to be used with a large diaphragm opening and yet secure a reasonably sharp image from foreground to distance. The difficulties of securing this depth of sharpness increase enormously with the increased size of plate or film, because of the longer focus lens required.

Conditions frequently arise where absolute sharpness is essential and where rapid exposures must be made. This result may in many cases be secured with a small camera, where a larger one used by the amateur would not give good results. Lack of sharpness is so pronounced in many negatives as to make them useless for illustrations or even as records.

The Finder.—A direct view finder is the best for general all around work, but too much dependence should not be placed upon it until it has been thoroughly tested and found to register exactly with the image produced by the lens on plate or film. The angle of view of these finders varies somewhat with the distance of the eye from it, and they must be tested, and then always used at a certain fixed distance from the eye to give accurate results.

In photographing objects close up all finders are practically worthless and a ground glass focusing screen is essential. This is due to the inability of the finder and lens to occupy the same place at the same time, although at distances from 15 or 20 feet to infinity this difference amounts to so little that finders are then serviceable. An accurate finder is extremely important. Many films and plates are rendered useless because the heads and feet of animals or important parts of plants, etc., are cut off, due to the use of an inaccurate finder. A direct view finder used at the level of the eye is often instrumental in producing better depth of sharpness because in many cases it eliminates superfluous foreground.

The reflecting types of cameras should never be used except for photographing animals under certain conditions or in other specialized work. They are entirely unsuited for general field work. In the experience of the laboratory men, the work produced by them is usually worthless.

Underexposure is the most common defect of films submitted for development. As a rule the higher priced the camera, and the more rapid the lens and shutter, the greater the chances for underexposure, when they are used by the inexperienced. For some reason there is a decided tendency on the part of those using high grade cameras to set the shutter at its maximum speed and use it there always, irrespective of light conditions, diaphragm opening, or subject. This results in a great waste of film each year and a corresponding loss in photographic records and illustrations. A safe rule to follow is never to make a "snap shot," if conditions permit of a time exposure on a tripod with a smaller diaphragm opening. This not only will produce a sharper image throughout, but will increase the latitude of exposure and result in a decided increase of good negatives.

Backgrounds.—A safe rule to follow is to use a background that will produce a decided contrast with the object photographed. In this case an error of overexposure will still leave sufficient contrast between subject and background for the laboratory man to "block out" the background and produce a satisfactory print.

In many cases, owing to incorrect exposure and unsuitable backgrounds, parts of the subject wanted have been entirely lost because the edges seemed to evaporate into the background. This condition becomes manifest when photographing plants like tobacco against a white background under the harsh light of the sun. The upper surface of the leaves reflects the sky and are sometimes lost into the ground. There are certain impossible photographic conditions, and when one is confronted by them it is an act of good judgment not to attempt to expose.

WHAT NOT TO DO.

Do not attempt to photograph anything growing under slat covers in the sunlight. The zebra-like effect is intensified in the negative. This and many other subjects demand a gray day to be photographed properly. Reds, greens, and oranges, except under extraordinary conditions, will photograph too dark. A ray screen when used with the ordinary film or plate will not materially benefit this condition. A ray screen is useful only when used with the kind of plate for which it was made.

Don't forget a "fast" anastigmat lens requires much more knowledge to use successfully than a slower "rapid rectilinear."

Don't experiment with ray screens, telephoto lenses, back combinations, etc., unless you can foresee the result.

Don't use the camera vertically to show a broad expanse of fields. This is a common error of the field men.

Don't take photos from moving trains; they are useless for illustrations and are seldom sharp.

Don't make exposures of more than one twenty-fifth of a second without using a tripod.

Don't expect the same quality in a "snap-shot" negative, camera held in the hand, that you can get by carefully focusing and using a tripod and giving a time exposure, circumstances permitting.

Don't make duplicate exposures of important subjects and give them all the same exposure. Vary the exposures in cases like this and one might be correct.

Don't expect good results on a hazy day, no matter how good your camera.

Don't attempt making "natural size" photos in the field unless somewhat experienced.

WHAT TO PHOTOGRAPH.

There is, however, more to the taking of good serviceable pictures than proficiency in the mechanics of photography. Every negative which can be successfully developed and made to yield a clear print is not necessarily of value to the department. A truly successful photograph is one which can be used to advantage in a publication of the department, is a useful record of valuable work, or preserves for reference some practical operation or scientific fact. In the early days of photography, when one could at best carry about only a few heavy wet plates prepared with considerable labor beforehand, photographers thought twice before they de-

*United States Department of Agriculture.

cided that a subject was worth one of these plates. Today, however, the exposing of a film means for the operator merely the pointing of the camera, the turning of the film roller, and the pushing of a button. The temptation to take snap-shots of everything that looks interesting is, therefore, very great. In consequence, there are many prints that are technically good, but for practical purposes are merely duplications of similar photographs which tell the same story, although they may have been taken under different conditions. Duplications of this character do not advance in any practical way the work of the department, but, on the contrary, hinder it by delaying the completion of the really important pictures.

The user of the camera should ask himself the following questions before he takes a proposed picture:

1. Is the picture merely a repetition in other places and with other actors of a photograph that is already available?

2. If it is a repetition, is there any useful purpose to be served by taking it in this particular locality?

3. Will the photograph illustrate clearly some fact or process, or is it in reality a portrait group of a number of people who may like to have their pictures taken or may interest the operator personally? In many cases it has been found that in the effort to include too many people in the scene the operator has placed his camera at such a distance that the picture does not reveal clearly the operation which it is supposedly designed to illustrate.

4. What will the picture teach by itself? If it is of use only when it is made a part of a series, the photographer must consider the probability of his being able to obtain at a future date the companion pictures which are essential to its value. Many negatives show only one stage in an operation and by themselves are of no significance.

5. Does the department need this picture and exactly to what use will it be put? The answer to this question will often keep the operator's finger from the button.

PHOTOGRAPH FOR A DEFINITE PURPOSE.

A photograph made as a scientific record should, of course, be devoted to this purpose alone and no other consideration should be allowed to interfere with the clearness and accuracy of the record. Where the purpose of the photograph is primarily educational, however, and especially in the case of photographs intended to arouse popular interest, it is most desirable to have some human or animal life in the picture. This lends human interest to the story. A collection of cooking utensils by itself is much less interesting than the picture of some one cooking with them. A picture of a field with men and animals in it is more attractive than the same field deserted. This element of interest, however, must be subordinated to the importance of bringing out unmistakably the real subject of the picture. The actors must draw attention to, rather than divert the mind from, the fact or process which it is intended to illustrate.

In many cases photographs are taken for the purpose of showing the condition of growing crops. Here amateurs frequently fall into two errors. They are disposed to include so broad a scene that each individual object is reproduced on too small a scale to convey any definite idea of its condition, and they omit to provide any standard by which the eye may unconsciously measure the size of the plants. In cases where this is a really important feature of the photograph, the operator will do well to put in the foreground some familiar object—it may be a human figure or a yard measure, or a hat, or a walking stick. Anything the size of which is unconsciously appreciated will serve the purpose. This is particularly important when near views of fruits or plants are desired. It is perfectly possible to take a picture of a blackberry that is 2 or 3 inches in diameter in the print that will convey a totally false impression of the actual size of the berry. In such cases if a coin, for example, is dropped in the foreground, the risk of involuntary deception will be automatically removed. In taking a series of photographs designed to show successive stages in the growth of a crop, each picture should be taken, if possible, from exactly the same distance and under the same mechanical conditions of focus and adjustment of lens. Where this precaution is not observed the successive pictures will not be on the same scale and the true comparative proportions of the plants will not be shown. With closely planted crops such as wheat, for example, the picture may also be greatly strengthened by cutting a small, even swath in the foreground. The fine stand which it is desired to illustrate is then shown in contrast to the smooth, closely cut stubble, and the lesson of the picture taught much more forcibly than when the foreground shows scattered or volunteer growths along the edges of the field. In taking pictures of this character it is usually desirable also to take a close view of the plants in order to show them in detail. With a small camera a picture of a large field of wheat is very apt to look like any other kind of a field, and, without the assistance of the caption, it is almost impossible at times to tell what the crop is, to say nothing of its condition.

The foregoing suggestions are intended for the use of those with little photographic experience and whose pictures are intended to convey a general impression rather than to record a scientific fact. Where the latter is the object, highly specialized apparatus and technical ability on the part of the operator are called for. Those who are not expert photographers but who contemplate work of this character will do well to consult with the photographic specialists of their bureaus or the section of illustrations and obtain advice from them upon the type of camera and lens to be used, and special methods of timing, lighting, and focusing. Photographers of the section of illustrations will be glad to give any information they can on these points, and practical suggestions and assistance to field workers as well. They will also be glad to explain, whenever these can be ascertained, the reasons for the failure of certain pictures. To enable them to do this, the operators should make a pencil record of each exposure, stating the conditions under which the picture was taken, and send this in with the film to the photographers. This record should state the time of exposure, the state of the light, the adjustment of the diaphragm, and similar information.

War Geology

GEOLOGICAL knowledge has heretofore been used for military purposes only in times of peace, the professional advice of geologists being resorted to in installing fortifications, with a view to getting information on the stability of slopes, condition of water supply, and similar problems. Since, however, the present war has shown to what unexpected extent the digging of trenches and shelters, installing of underground mine galleries, the water supply and drainage, are important factors even in field battles, it will be readily understood that geological knowledge on the theater of war is bound to prove of the highest utility and sometimes decisive importance.

In a lecture recently held at Heidelberg, Prof. Wilhelm Salomon, Director of the Geologico-Palaeontological Institute of that University, discusses the several cases in which geology is likely to be of material help to the strategist. These may be briefly summarized as follows:

1. Ascertaining the stability of slopes in trenches, shelters, entrenchments and fortifications.

2. Determining the speed of digging cavities (trenches and mine galleries).

3. Supplying satisfactory drinking water by means of temporary or permanent aqueducts safe against destruction by the enemy.

4. Disposing of rain water and sewage in trenches, shelters and fortifications.

5. Supplying building materials for the installation of fortifications, bridges and roads.

6. Supplying the country with mineral raw materials.

As regards, first, the stability of slopes, it should be remembered that every kind of rock has what is termed a maximum slope. Whenever the gradient of an artificial slope exceeds this maximum, it is bound to slip, either in a slow process of decay, which even in fortress building, may be left out of account for a considerable length of time, or rapidly and continually, with each rain, each spell of frost and each shock of some intensity. It is thus of enormous advantage, in the case of variable soils, to choose the most resisting material, and, if possible, to compel the adversary to dig himself down into inferior material. As regards, next, the speed of digging, in connection with the installation of trenches and mine galleries, it may be of decisive importance—as shown by this war—whether a body of troops will succeed in digging themselves down to sufficient depth, in the course of a few hours, to be safe against the enemy's fire. This, however, is possible only in loose rocks, and an expert able to tell at a glance from the appearance of the soil whether trenches could be installed of sufficient depth and at proper speed, is therefore bound to prove a most valuable adviser. While in the large lowlands of Northern Germany, Northern Belgium, Poland and Rhenania, there is practically everywhere loose ground down to sufficient depth, the trias, Jura and chalk formations on the western theater of war, where tens of thousands of trenches have to be dug at a moment's notice, are altogether different and comprise a rapid alternance of hard and soft rocks. Test borings with a geological hand drill are likely to settle the question in a few minutes.

In installing underground mine galleries, it is of even higher importance to be able to tell from the condition and arrangement of the strata whether there is a possibility of penetrating at a sufficient speed to sufficient vicinity of the enemy's positions. A knowledge of the thickness of strata and the condition and arrangement of rocks is of paramount importance in this connection, and victory may come to the party best equipped with geological experts.

The third case enumerated in the above list is the supply of satisfactory drinking water. On account of the great difficulty experienced in taking drinking water to the trenches, it is obviously of paramount importance to be able to obtain such water on the spot, the more so as existing pits are often destroyed by the enemy. There are two processes available in this connection. The first is to sterilize rain, river or lake water of poor quality by boiling or the addition of chemicals, which is frequently done with good results. When, however, there is absolutely no water available—or when there is no means of making it suitable for consumption—it should, as far as possible, be derived from the ground. The facts to be ascertained in this conection are whether the underground water level is hidden in the soil at small depth, and whether impervious layers on which the water accumulates are inserted into the permeable strata.

Another problem mentioned in the above list is the disposing of rain water and sewage in trenches, shelters and fortresses. One of the most objectionable features from a sanitary point of view on the western front during the first half of last Winter, has been the accumulation of large amounts of water in the trenches. Pumping has, in this connection, been resorted to in many cases, but the pumped-out water would frequently flow back into the positions. In the case of heavy rain, moreover, pumping would prove entirely inadequate.

The geological expert frequently is able to come to the rescue and to ascertain by a few minutes boring—unless, indeed, he knows it from theoretical study—that there is a previous layer of sand, gravel, etc., at a small depth below the impervious ground of the trench. In such cases, a few narrow galleries dug into the ground or a few pipes inserted will suffice to cause the water to drop into the deeper layers, thus draining the trenches and shelters. The same process will allow sewage and liquid feces to be supplied to the stream of underground water, thus preventing the country from being contaminated. The disposing of sewage plays a not unimportant part in fortress building.

The fifth case to be considered is the supply of building materials for the installation of fortresses, roads and railways. The importance of this application is by no means limited to times of peace, many fortresses having been rebuilt in the present war, while roads and strategic railways were frequently constructed anew. Since the co-operation of the native population, for obvious reasons, cannot be relied upon, an accurate knowledge of the geological condition of the country will be of the highest value. As a rule, however, the supply of building materials is a problem dealt with in times of peace, in conjunction with geological experts.

The last case considered by Prof. Salomon is the supply of the country with mineral raw materials. There are a great many deposits which, in times of peace, on account of international competition, cannot be exploited, which, however, assume paramount importance, as soon as, in wartime, the supply of mineral raw materials for certain industries is discontinued partly or entirely. In fact, the supply of these materials then no longer depends on prices, the important thing being that they are at all available. Much has been done in this direction during the present war, in Germany, where, on account of the variegated condition of the ground, there is an abundance of the most diverse mineral deposits, which have supplied substitutes for some of the most vital raw materials.

Salomon is of the opinion that in the strategic plans of the future the geological factor should be given increased attention, already in the preparatory work done in time of peace. Special geological officers should therefore be appointed, while many young geologists could, in wartime, be called upon to assist in the solving of the problems raised by war.

Alcohol for Industrial Purposes

THE development of many British industries has been severely checked by the want of pure alcohol, free from duty; and it is only during the last year that the Excise Commissioners have altered the regulations so as to enable manufacturers to compete on equal terms with their foreign competitors. The current issue of *The Journal of the Society of Chemical Industry* (1915, page 53) publishes these regulations as an official notice. The precautions to prevent the improper use of such duty-free alcohol include proof by the manufacturer that such spirit is essential to his industry, control of the alcohol by a revenue officer, and the addition to it of such approved substance as shall render it unsuitable and unpalatable for drinking. Regulations have also been made for the use of methyl alcohol and gasoline, free of duty, for industrial purposes.

The Rifle and Its Bullet*

A Short History of Firearms and the Bullets They Use

THE earliest hand gun, the arquebus, had an iron barrel 6 feet long, with a funnel-shaped mouth, into which the gunpowder was poured from a powder horn. The bullet, of lead or stone, was then dropped in and driven down with a wooden ramrod. In firing, the muzzle was supported by a forked stick, and the charge was exploded by applying a lighted match to the touch-hole. The bullet weighed 2 ounces and the range was about 300 paces. The wheel lock, which produced sparks by friction between a bit of pyrites and a steel wheel, was invented about 1517.

Early in the 16th century the arquebus was superseded by the lighter match-lock musket, but the preparations for firing were still so tedious that the artillery fired thrice as rapidly as the infantry in a battle in 1634, and the musketeers fired only 7 volleys during an 8 hours' battle in 1638.

Gustavus Adolphus, the Swedish king, reduced the weight of the musket to 12 pounds and the caliber to 0.72 inch, which remained the standard caliber until the 19th century. The flint-lock, in which a flint attached to the cock struck sparks from a steel plate, came into use in France in 1640. A hundred years later the introduction of the iron ramrod increased the rapidity of fire to 5 shots per minute.

Even in the time of Frederick the Great the projectile was a spherical bullet of soft lead, weighing about 1 ounce, with an effective range of 100 yards and a penetration little greater than that of a cross-bow bolt. About 1830 the introduction of the fulminate percussion cap and lock, and other improvements, produced a weapon capable of disabling an opponent at 300 yards.

Longitudinally groved guns were made in 1490 and spirally grooved, or sifted, guns in 1563, but their use, prohibited by priests and princes, did not become general until 1840. Pointed bullets, too, were made before the year 1600, but it was long deemed unchivalrous to employ them in battle, and they were used only in

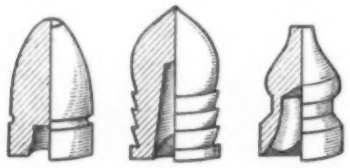


Fig. 1. Minié. Nessler. Podewits.

hunting and target shooting. In the old muzzle-loading rifles the bullet, after it was rammed down upon the charge, was somewhat flattened and forced into the rifling by the ramrod, with the aid of a projection, or "thorn," on which the bullet rested. The operation was facilitated by deep grooves in the bullet. Rifles of this construction were recommended for the French army in 1846.

In 1849 the French Colonel Minié invented the expansion bullet, which made the ramrod superfluous. The base of the short-pointed bullet was deeply hollowed and covered by a concave plate of sheet iron or baked clay, which, forced into the cavity by the explosion of the charge, pressed the walls of the cavity into the rifling. Similar expansion bullets were devised by Nessler and Podewits (Fig. 1). The range of the Minié rifle was 700 yards, the caliber 0.73 inch, the weight of the bullet nearly 2 ounces. It proved so efficient in the Crimean War (1853-1856) and at Magenta and Solferino in 1859, that little attention was given to the breech-loader, that had been introduced in Prussia in 1841.

In France, Chaumette had constructed a breech-loader in the middle of the 18th century, and Pauli had patented another breech-loader, but these weapons lacked a very essential feature—the combination of bullet, charge and primer in a single cartridge, which was effected by Johann von Dreyse in 1827.

The cartridge was first made for the smooth-bore muzzle-loader, but Dreyse established a gun factory with the aid of the Prussian government, and produced in 1836 a breech-loading rifle, the famous Prussian needle gun. The caliber of the gun was 0.62 inch, while that of the long-pointed bullet was only 0.54 inch. The paper cover of the cartridge did not make a perfectly gas-tight joint, and a loss in ballistic power resulted, but the smaller caliber of the needle gun, its flatter trajectory, due to more inclined rifling, and its greater rapidity of fire, due to the cartridges, made it greatly superior to the Minié rifle. The tendency to reduce calibers as much as possible commenced at this epoch. The name needle gun was derived from the needle which was thrust through the powder charge to detonate the primer, which was placed between the bullet and the powder.

The Prussian needle gun proved so superior to the Austrian muzzle-loaders in the war of 1864-1866, that France and other countries adopted the new construction. In the war of 1870 the French infantry was

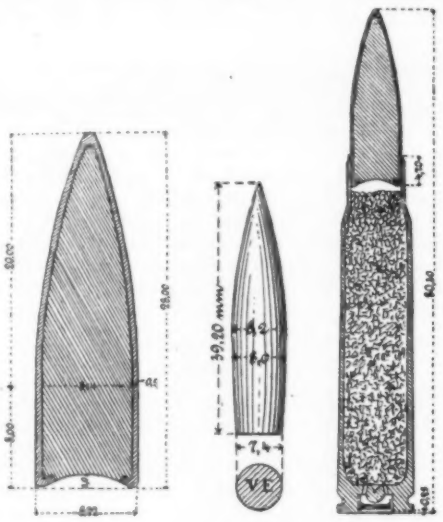


Fig. 2. German S bullet. French D bullet. German S cartridge

armed with the Chassepot rifle, introduced in 1866, which was nearly free from the defects of its prototype. The Chassepot was a needle gun using a paper cartridge and a pointed bullet having a length of 1 inch and a caliber of 0.44 inch. This caliber was adopted by Germany in 1871. At the same time England adopted the Henry-Martini rifle, with a caliber of 0.46 inch, which was superseded in 1889 by the Lee-Medford repeating rifle.

Repeating or magazine guns had been constructed in the days of paper cartridges, but the danger of exploding several cartridges at once had prevented their adoption. This danger was removed by the metal cartridge, invented in America in 1861. The first repeating rifle used in any army was the Spencer, adopted by the United States in 1862.

After the Franco-Prussian War all countries adopted calibers of about 0.44 inch. In the French Lebel rifle (1886) the caliber was reduced to 0.32 inch, which was

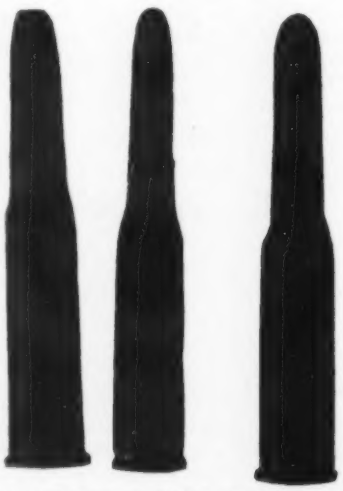


Fig. 3. Japanese cartridge. Russian cartridge.

long regarded as the smallest practicable caliber. As the caliber was diminished the relative length of the bullet was increased to about 4 calibers, in order to retain sufficient weight, and the need of a more powerful explosive to act upon the small base of the bullet became imperative.

The earliest smokeless powders—Vieille's (1888), Nobel's and the German "leaf powder" (1889) consisted essentially of guncotton. Mixtures of guncotton and nitroglycerin were then adopted, under the names "cubical powder" (C 89) in Germany, filite and ballistite in Italy, and cordite in England. The intense heat generated by these mixtures rapidly burned out the guns. The powders now in use are essentially similar to Nobel's mixture of guncotton and collodion.

The cleanliness of smokeless powder made rapid-fire guns possible, and its great explosive force allowed the caliber to be diminished still further. Italy reduced the caliber to 0.26 inch, the United States to 0.24 inch, and successful experiments were made with a caliber of 0.20 inch.

Meanwhile, important changes had been made in the form and material of the bullet. Soft lead bullets are very suitable for smooth-bore guns, but they leave particles of lead in the grooves or rifles, and thus diminish the diameter of the barrel. They are also deformed in the gun by the violent explosion of smokeless powder, and are more seriously deformed on striking with great velocity. The expedient of hardening the lead by adding 3 per cent of antimony did not long suffice to resist the constantly increasing force of the powder. A solid steel bullet would be too light, but in 1875 the German Major Bode conceived the idea of pressing a leaden core into a jacket of nickel-plated steel, open at the base. This construction, more or less modified, was promptly adopted in all countries except Switzerland. In the compound bullet, invented in 1884, the parts are united more firmly by pouring the molten lead into the interiorly tinned jacket.

The rifle bullets which are now used by various nations differ little in size, form and weight. The sharply-pointed German S bullet (Fig. 2) is 28 mm. long and 8.22 mm. (0.33 inch) thick. It weighs 10 grammes and acquires from a powder charge of 3.2 grammes an initial velocity of 860 meters per second and a maximum effective range of 4,000 meters.

Fig. 4. Russian. Swiss.

The French D bullet (Fig. 2) is made of bronze containing 90 per cent copper, 6 per cent zinc and 4 per cent nickel, and is electroplated with copper. It is 39.2 mm. long and 8.2 mm. (0.33 inch) thick. It weighs 12.8 grammes and acquires from a charge of 3.1 grammes an initial velocity of 720 meters per second, and a maximum effective range of 3,600 meters.

In 1871 Wilhelm and Paul Mauser constructed a breech-loading rifle with an improved breech and simplified loading mechanism. In 1884 this was converted into a repeating rifle, having five cartridges inclosed in a case. The full case was inserted in the magazine, from which the empty case was expelled automatically when all of the cartridges had been fired. In the model 98, which is now in use, the 5 cartridges are merely attached to a strip of lead.

Magazine rifles of the Mauser type are now used by Germany, Turkey (caliber 0.306), Serbia (0.28), and Japan (0.32 and 0.26), while the Mannlicher system is employed by Austria (0.32), Italy (0.26), and Holland (0.26). France still retains the improved Lebel rifle, introduced in 1888, with 8 cartridges, which are inserted successively in a tube beneath the barrel—a very inconvenient arrangement. Russia uses the Nagout-Mossin (0.305), England the Lee-Enfield (0.308) with 8 cartridges in the magazine, and Switzerland the Schmidt (0.30). Only the tip of the Swiss bullet is protected by steel, the greater part being wrapped with paper and greased (Fig. 4).

The effectiveness of a bullet depends upon its kinetic energy, which is proportional to the product of its mass by the square of its velocity. The mass of the modern rifle bullet is small, but its velocity is so great, even at a range of 2,000 meters, that it goes smoothly through bones as well as soft parts, and disables, if it does not kill, its victim.

Not all bullet wounds, however, are smooth perforations with small entrances and exists. In 1866 experiments were made on corpses with the Chassepot rifle at short distances. The entrances of the wounds corresponded with the size of the bullets, but the exits were

* Abstract of an Article by Dr. H. L. Heussner in *Prometheus*.

7 to 13 times larger, arteries and veins were severed, and bones were frightfully mangled to considerable distances. These observations were confirmed on the battlefields of the Franco-Prussian War, where strikingly large wounds were inflicted. In some cases the exit of the wound was 10 to 20 times the size of the entrance, forming a conical hole as big as a child's fist, from which various soft tissues protruded. Some of these big holes were caused by bullets, which had passed only through soft parts, without producing bone splinters. In some cases fragments of tissues protruded from the entrance opening, in a direction opposite to that of the shot. The muscles around the path of the bullet were converted into a pasty mass, and the bones were shattered into fine splinters. Sometimes the entire skull was shattered, as if by an explosion, by a bullet striking the middle of the head. Wounds like these had previously been observed as the result of shots fired at very close range, as in suicide, but now they were produced at distances of 200 and 300 yards.

After the war this explosive action of the small caliber bullet, in certain conditions, was investigated, and it was found to occur only within a range of a few hundred meters, and to increase in violence with the water content of the wounded part.

A bullet entering an organ filled or saturated with water may be likened to a cork driven into a bottle completely filled with liquid. In each case the vessel is ruptured by hydraulic pressure transmitted to every part.

The greater the velocity of the bullet, the more violent is this explosive action. Of two equally swift bullets, the one having the greater cross-section (either natural or due to flattening on impact) produces the greater explosive effect. The velocity, however, is the most important factor, so that the explosive action of modern rifle bullets extends to a greater range, and is more violent at the same range than that of the older and slower bullets. The explosive effect is produced only in organs saturated with water, like the brain, spleen and liver, and in organs filled with fluid, like the stomach, intestines and bladder.

Bullets with long, tapering points, and with the center of gravity near the base, are sometimes turned crosswise or end for end, by striking small obstacles, such as grain stalks. The reversed bullet makes a bad wound, and the bullet that strikes cross-wise makes a worse one, because it is larger in section and it usually expends its whole energy in the body, and invariably remains there.

As a rule, however, the wounds caused by the modern small and swift rifle bullet are benign, and heal quickly if they do not kill outright. This has been confirmed in the present war.

Submarine Periscopes*

The Principles of Construction in Various Types of Instruments

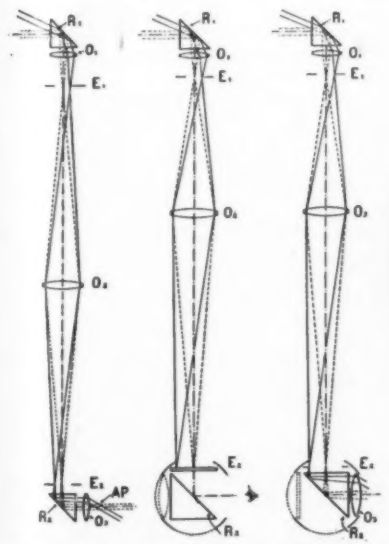
THE periscope enables the commander of a submarine to make observations and to direct the course of his vessel almost as well when it is submerged to a depth of thirty feet or more as when it is on the surface of the water. The construction of this apparently simple device has presented a difficult and complex problem, as will appear from an examination of the various optical combinations which are used in German submarines.

The simplest type is represented in Fig. 2. The top of a steel tube about twenty feet high carries a total reflection prism R_1 which reflects rays coming from external objects to a lens O_1, of rather short focus, which forms a virtual image of the objects of the focal plane E_1. This image is projected by the lens O_1 to the focal plane E_2, at the bottom of the tube, and this second image, erected by the prism R_2, is viewed with the eyepiece O_2, which gives an enlargement of 1.5.

Experience has shown that this enlargement is required to give the objects their natural apparent size and distance. With a magnifying power theoretically equal to 1 the objects appear smaller and more distant than they are in reality. The field of view embraces about 45 degrees, and the entire horizon can be explored by rotating the tube.

This simple periscope produces very sharp images, but as it is monocular, it gives but a vague impression of distance, and it soon fatigues the eye. The endeavor to construct a binocular periscope has been abandoned because of the limitation imposed by the interocular distance (2.5 inches) upon the diameter of the lenses and, consequently, upon the brightness of the image. It seems to the writer that this difficulty might be overcome by a construction similar to that of the prismatic binocular field glass.

The compound periscope illustrated in Fig. 3 permits binocular but not stereoscopic vision. The upper part of the instrument is like that of the simple periscope, but at the lower end a real image is formed on a ground glass screen E_2, and this image is viewed by reflection from the silvered hypotenuse of the prism R_2. The screen, the prism and an eye-piece O_3 are mounted



Figs. 2, 3 and 4. Simple periscope; compound periscope; compound periscope with eye piece.

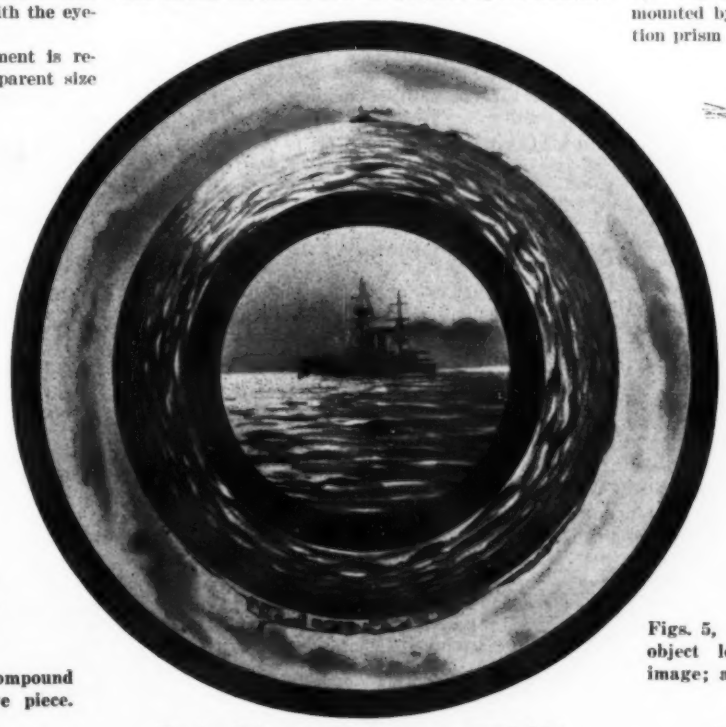


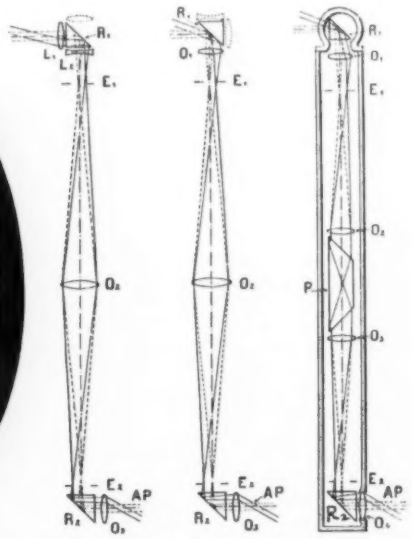
Fig. 1.—Enlarged partial view, surrounded by annular panoramic view as seen through a periscope.

in a drum which rotates on an axis in the plane of the silvered surface. When this drum is turned through 180 degrees the real image becomes a virtual image, which is viewed through the eye-piece by internal total reflection, as in the simple periscope (Fig. 4). Each method of observation has its special advantages and inconveniences. The ground glass screen lessens eye strain, but it cannot be used in a weak light.

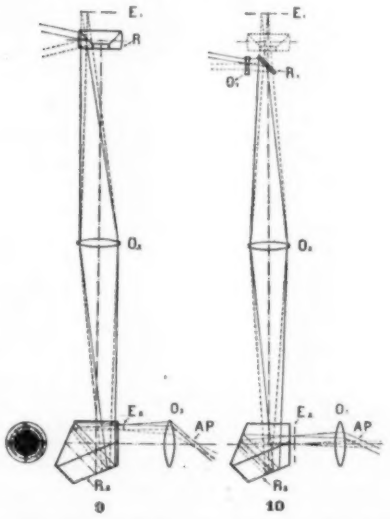
The magnifying power of 1.5 is often insufficient for distinguishing certain details. Greater enlargement is obtained, without increasing the length of the tube or greatly diminishing the brightness of the image, by employing a tele-objective combination of a converging lens L_1 in front of the upper total-reflection prism R_1 and a diverging lens L_2 below the prism (Fig. 5). These two lenses, the prism and the ordinary objective O_1 are mounted in a drum, by rotating which through 180 degrees the ordinary objective can be used in the usual way, except that the reflection takes place at the silvered external face of the prism (Fig. 6).

From five to ten seconds are required to sweep the entire horizon with any of the periscopes described above, and the operation requires some effort, owing to the friction between the tube and its water-tight bearing. Furthermore, the observer is compelled to move, with the eye-piece, about the axis of the periscope. If the rotation were confined to the top of the instrument, the eye-piece remaining fixed, the image would rotate, so that a half turn would make the horizon vertical, and a whole turn would invert everything. It is possible, however, to keep the image in its normal position by means of an erecting prism moving so as to compensate the rotation of the periscope top.

This is the principle of a panoramic periscope (Fig. 7). The tube is fixed and incloses an inner tube surmounted by a glass cap, which contains a total-reflection prism R_3. This inner tube can be rotated by turn-



Figs. 5, 6 and 7. Instrument with coverging object lens; tele-objective and direct-reflected image; a panoramic periscope.



Figs. 9 and 10. Periscopes with annular fields.

* Translated from Ernest Constet's article in *La Nature* for the SCIENTIFIC AMERICAN SUPPLEMENT.

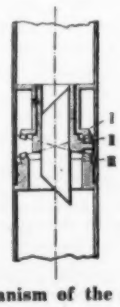


Fig. 8. Mechanism of the erecting prism.

ing a handle. The reflected rays are converged by the lens O_1 upon its focal plane E_1, which is also the focal plane of a second lens O_2. On leaving this second lens, therefore, the rays from any given point of the object are parallel. Then they traverse the tetrahedral erecting prism P and a third lens O_3, which forms at E_2 an image which is viewed by means of the prism R_2 and the eye-piece O_4.

The mounting of the erecting prism (Fig. 8) carries a bevel pinion *III*, which engages two racks, *I* and *II*, of which the former is connected with the inner tube of the periscope. The gearing is so constructed that the angular displacement of the erecting prism is half that of the upper prism R_1. The result is that the image always retains its erect position.

In order to observe successively every part of the horizon, it is necessary only to rotate the inner tube, which moves easily on ball bearings, while the eye-piece and the observer remain motionless. This operation, however, cannot be performed instantaneously and, in conditions which demand assiduous observation in every direction, continuous rapid displacement of the field of view might cause the pilot to "lose his bearings" temporarily.

A simultaneous view of the entire horizon is obtained by means of the periscope with annular field (Fig. 9). The top of the tube carries an annular lens R having a spherical outer surface and a silvered ellipsoidal inner surface. This lens refracts and reflects rays from all points of the field to the objective O_2 which converges them upon the focal plane E_2. The panoramic image thus formed is seen in its true proportions only when it is observed with the eye-piece O_3 through the pentahedral prism R_2. This annular image includes all surrounding objects, but these appear smaller and more distant than they appear to the naked eye. In order to estimate dimensions and distances accurately, the circle surrounded by the annular image is utilized for the projection of an enlarged partial image, by means of the diverging lens O_4 and the mirror R_3 (Fig. 10). The observer sees, therefore, at the center of the annular panoramic image an enlarged view of a part of the scene, about 25 degrees in extent. By turning the inner tube of the periscope every part of the field can successively be examined in detail.

Protecting Congested Districts in Cities*

Causes of Conflagrations, and Methods by Which They Can be Prevented

In the heart of every large city will be found a congested district. Many weighty problems arise through the growth of these congested districts. One of the most important of these is the protection of property and life therein against conflagration danger, which is the subject of this address.

It is said that the greatest congested district in the world to-day is in New York city, extending from Fourteenth to Chambers Street, and comprising an area of 2,088 acres. The next in the United States in size and value is in Chicago, covering 752 acres, followed by Philadelphia, 550 acres; Baltimore, 417 acres; Boston, 335 acres; San Francisco, 313 acres; St. Louis, 297 acres; Buffalo, 248 acres; Cleveland, 213 acres, and Pittsburgh, 212 acres. All other large cities contain corresponding congested districts. From these figures we may understand the magnitude and value of these districts and the gravity with which this subject should be considered.

The elimination of the conflagration hazard in the congested districts of our cities is a subject of the greatest interest to every insurance commissioner, not only on account of the great danger to life and property, but also because the conflagration hazard is the final refuge of the insurance "combine" and applied by it to all districts of all cities under all circumstances, and thus made the universal excuse for excessive premium rates and justification for the "combine's" monopoly. It is to be deeply regretted that instead of trying to find a remedy for the conflagration hazard the insurance interests ever industriously foster the idea that on account of this alleged peril the companies are entitled to the same sympathetic license and immunity from prosecution for violation of State and National laws which is tacitly extended to soldiers and sailors because they risk their lives in deadly battle or face the dangers of the stormy deep.

For a conflagration to be possible there must exist concurrently-made defective conditions such as use of unserviceable building material, faulty architectural designs, general carelessness in construction, as well as undue accumulation of fire-breeding materials. These conditions are permitted to continue by reason of insufficient and unenforced State laws and municipal codes, as well as on account of the failure of the insurance "combine" to encourage protective measures by allowing adequate reduction in premium rates therefor. The "combine" also actually countenances fires by permitting a general system of overinsurance.

The chief consideration in fire protection of the congested districts of cities is the prevention of conflagration. This, of course, does not mean that we should fail to consider ordinary fires because, in the first place, these, when all taken together, cause considerable loss, and, in the second place, each ordinary fire is a potential conflagration. Fortunately the same preventive measures are effective against both.

In the historical conflagrations, from the great fire of London in 1666 down to those of Chicago and Boston in the seventies, the great losses were due to the combustible character of the building construction then universal, as well as the insufficiency and inefficiency, as judged by modern standards, of the fire fighting equipment of those days. I believe, however, that under present day conditions of a large proportion of fireproof and sprinklered buildings in the congested districts of most cities, and the remarkable efficiency of modern fire fighting equipment, the liability of serious conflagrations in any of our important cities has been immensely reduced. There remains nevertheless some possibility that a conflagration may occur in such districts of our cities, so that we should consider anxiously and carefully some method by which this possibility can be entirely eliminated, and the congested districts of our cities immediately rendered secure from all danger of a conflagration.

If all buildings in such districts were made fireproof, this alone would not prevent all danger of conflagration. Experience has demonstrated that ordinary fireproof buildings cannot unaided protect their occupants and contents, in a conflagration. The heat will quickly break through ordinary windows and set on fire the combustible contents, which will usually be completely destroyed, leaving nothing but the windowless walls, as in the Edison plant. We must, consequently, seek other means than simply the construction of fireproof buildings to render a congested district entirely safe, although such buildings help to prevent an ordinary fire from spreading.

What is needed is some method which will remove every possibility of a conflagration occurring in congested districts, and which is also financially practicable. Fortunately, experience and the studies of architects, engineers and fire-prevention investigators have discovered and developed means for rendering the congested districts of all cities practically fireproof, and this at a cost which is not excessive. While there are a number of minor measures, each capable of contributing something to this end, there are two which are agreed by competent authorities to be of paramount importance. These are: (1) The protection of all elevator, airshafts and floor openings, by metal doors or wired glass and a similar protection for every exterior opening, and (2) the installation of a complete automatic sprinkler equipment in every building in a congested district.

It is possible that for a few of the worst "conflagration breeders" the only rational remedy is removal, but for a large majority of the buildings, this is not necessary. Take any well-built concrete, brick, stone or protected steel frame building, give it a non-combustible roof, protect every skylight, every wall opening, elevator shaft, stairway, either by iron doors, wired glass windows, or by automatic fireproof shutters, and above all, provide it with an adequate sprinkler system, and the building will be safe from itself, and at the same time become a means of protection to its neighbors. Even a fire trap can thus be turned into a redoubt against conflagrations.

In order to properly understand how these means are sufficient to render the congested district of a city fireproof, we should first consider what a conflagration is and how it spreads. A conflagration is a fire which extends beyond the building in which it originated, or "a fire so hot as to keep firemen at a distance." It is the way in which the fire spreads which is the essential characteristic of a conflagration. If a fire spreads only by the contact of flames or the dropping of burning brands on other buildings, it can be readily controlled by any efficient fire department. However, in a true conflagration the communication of fire does not happen in this way, but is through what is commonly called the "hot-blast" action. This "hot-blast" action is ordinarily regarded as the effect of the intense heat from the large fire. This is supposed to be the reason that buildings burst into flames before they are touched either by brands or actual flame. In the accounts of every great conflagration will be found mention of instances of this kind. In the same descriptions there usually occur also instances where buildings have wholly or partially escaped the effects of the fire, although in the path of the conflagration, and surrounded by buildings which have been utterly destroyed. Their escape cannot be attributed to the material of which they were composed. If the intense heat alone was the cause of the advance of the conflagration, there would be absolutely no way of explaining why these buildings escaped. In the Baltimore fire of 1904, the two-story Safe Deposit Company building was entirely unharmed, the brick work and iron shutters showing but little effect from the terrific heat.[1] The Alexander Brown building, likewise a two-story building, but protected by wired glass windows, was also practically unharmed.[2]

The explanation of all these strange occurrences is that in conflagrations buildings are not set on fire from a distance by radiated heat, however intense, but in an entirely different way. I will attempt to explain briefly what this so-called hot-blast action really is. When a fire attains the magnitude of a conflagration, we have intense heat acting on immense amounts of combustible substances. This intense heat roasts out of the partially consumed material immense volumes of combustible gases, just as such gases are roasted out of the coal in the retorts of a gas factory. These combustible gases will burn whenever they come in contact with sufficient oxygen of the air, but in a conflagration the volumes generated are so enormous that sufficient oxygen cannot be immediately obtained from the surrounding air to at once consume all these gases. The result is the generation of large volumes of unconsumed combustible gases at very high temperatures, which drift with existing air currents. When these masses of superheated gases strike a building, the heat will break out ordinary window glass at once, so that the gas gains access to the interior of the building, where sufficient oxygen will be found to allow combustion of the gas to take place. The heat of the gas itself is usually sufficient to bring about self-ignition, just as in the cylinder of a Diesel engine. It is probable also that ignition sometimes occurs from lights in the building or even from matches ignited by the heat. The same phenomenon sometimes occurs when a large volume of such gases strikes a tree in full leaf. The mass of leaves detains sufficient oxygen for combustion so that the tree top bursts into flame. Those of you who have watched large fires of any kind have doubtless noticed the bursting forth, high up in the air from time to time, of sheets of flame, separate from those issuing directly from the fire. This is another phase of the same action. In these cases the superheated, combustible gas rises upward until a place is reached where sufficient oxygen is available to sustain combustion. Then, either ignited by its own heat or by the sparks and brands also carried upward, the gas takes fire and we have a flash of flame.

It is easy to understand how a conflagration spreads in this way with such amazing rapidity and soon becomes absolutely uncontrollable. It is as if the buildings in the path of the conflagration were saturated with gasoline. It explains why, when the genuine conflagration action sets in, the best fire-fighting equipment is practically helpless.[3]

An account of the San Francisco conflagration says: "There were pauses at some of the big buildings, almost extinction; then gases would ignite in those great piles, lighted *via* the unprotected windows, and everything burnable within them seemed to be on fire at one time."[4]

Applying this knowledge to the prevention of fires, we are readily able to understand how the protection of all openings in buildings with iron shutters or wired glass windows, together with the provision of automatic sprinklers on the inside will absolutely prevent the spread of a conflagration. Suppose that a fire has become a conflagration and these unconsumed gases drift toward a neighboring building, the heat will be radiated into the interior of the building through the wired glass or iron shutters, not usually sufficient, however, to ignite the combustible material within the building, at least not for a considerable time. Instances are known where the heat was so intense as to partially melt the glass in the wired windows, but nevertheless the fire was kept out.[5]

* From an address by Rufus M. Potts, Insurance Superintendent of Illinois, before the National Convention of Insurance Commissioners at Monterey

[1] Cyc. Fire Prevention and Insurance. Vol. 1, p. 23.

[2] Cyc. Fire Prevention and Insurance. Vol. 1, p. 35.

[3] This "hot-blast" action has been well explained by Mr. S. H. Lockett, in an address before the twenty-fifth annual meeting of the Fire Underwriters' Association of the Northwest, and can be found on page 90 of the proceedings of that association for 1904, to which I refer anyone desiring further details.

[4] Cyc. Fire Prevention and Insurance. Vol. 1, p. 51.

[5] On page 44, Vol. 1, of Fire Prevention and Insurance is a striking photograph of a window which passed through a fire where the heat was so intense that a part of the wired glass melted and ran down onto the window sill, but nevertheless, nothing inside the building took fire, even though it was not protected by automatic sprinklers.

But suppose that the building is, as it should be, also protected by automatic sprinklers, then if the heat radiated through the wired glass windows or iron shutters becomes dangerous, the sprinkler heads close to the opening will spout forth a spray of water which will prevent the temperature rising to such a point that ignition of contents can take place. But even if the protected windows or other openings should fail and fire spread to the interior of the building, the immediate opening of the sprinklers would turn loose a spray of water which would cool down the gases, and also extinguish the flames, so that the fire would be either entirely quenched or the action reduced to such an extent that the generation of combustible gases would cease, which would stop the conflagration action. In any case, the building will stand and the flood of unconsumed gases will be deflected upward and either burn harmlessly in the air or become so cooled as not to burn. All that is then necessary is to prevent new fires originating from any burning brands carried by the wind. This can easily be done by an efficient fire department if all roofs are non-combustible.

Of course, if all of the buildings in any congested district were protected with iron shutters, wired glass windows and automatic sprinklers, kept at all times in good operating condition, it would be impossible that any fire would ever attain such size that this "hot-blast" action would begin. Consequently, the only time when the deflecting and cooling functions of these buildings would come into play would be when a conflagration originating in an outside unsprinklered district and driven by a high wind, might approach a congested district. In such case, it is impossible that the conflagration could pass more than one or two tiers of buildings properly protected and sprinklered.

I have read with much interest a report of this discussion. While there was naturally some difference of opinion as to the degree of effectiveness of automatic sprinklers alone to absolutely prevent conflagrations in congested districts, yet every speaker endorsed and recommended them as the best known means for this purpose.

Some of the fire chiefs seemed to think that the form of statement of the topic implied that fire departments were to be abolished and automatic sprinklers alone depended on to extinguish all fires in congested districts, and a number of instances were related where, owing to peculiar circumstances, sprinkler equipments had required aid from fire departments. No reasonable person would expect to dispense with fire departments, even if congested districts were protected and sprinklered in the most scientific manner, and all I say concerning the protection of such districts assumes the presence of an efficient fire department.

The instances narrated of failure of sprinkler equipment to extinguish fires were all cases where either the equipment was defective or had been tampered with by incendiaries, or where, owing to the character of the risk, such as explosive or very inflammable articles, the fire instantly spread throughout the building, or where, because the goods were stored on very deep shelving or on account of other special structural features, the water from the sprinklers was unable to reach the fire.

These are cases which occurred under present-day conditions of voluntary, non-standardized sprinklering, and would be almost wholly eliminated it standardized sprinklering was made compulsory, and this was frequently inspected by a vigilant fire department, while at the same time proper rules were rigidly enforced regarding the storage in congested districts of explosives or highly inflammable substances, such as gasoline and oils, as well as the internal arrangement of the contents in buildings in such a manner that water from the sprinkler heads could reach every part.

There would, of course, always remain a remote possibility that fires might gain some headway from incendiarism where the sprinkler equipment had been purposely disabled, but it would be impossible for such a fire to spread into other sprinklered and protected buildings, so as to become a conflagration, and the possibility of a widespread conflagration would be as remote as the danger that the world will be destroyed by colliding with a comet.

A discouraging phase of this matter is the fact that instead of encouraging the protection of openings and the installation of sprinkler equipments, the insurance interests have been passive, and except where compelled to do so by competition with mutuals, have refused to give adequate reduction in rates for these improvements. The reason is apparent. The mutuals have, by means of sprinkler equipments, reduced the cost of fire insurance as low as one-tenth of the "combine" rate, and maintain this reduction permanently. If the stock companies had to reduce their premium rates accordingly, as they would have to in order to prevent all business going to the mutuals, their revenues would be sadly reduced.

I would make the further recommendation that, whether in congested districts or not, all tall buildings in which, on account of being used for manufacturing purposes, or for any other reason, large numbers of people congegrate, should be required by law to have "independent tower" fire escapes, or similar safety devices. One of the best forms of these is a fireproof shaft within the building, with no openings into the interior of the building. Access to the shaft is obtained through fireproof doors opening on metal balconies, on which balconies doors also open from the interior of the building. In case of fire, all the occupants of any floor have to do is to step on the balcony, walk a few feet, step into the fireproof tower and descend on the stairways therein, absolutely secure from danger by any fire between them and the ground.

While, of course, wooden buildings should not be permitted in the congested districts, still wooden factories and other buildings, having non-combustible roofs, by a proper sprinkler equipment, including water curtains on the outside, can be rendered so nearly fireproof that they can safely be permitted in outlying districts of large cities where they would otherwise be inadvisable. The cost of such an equipment is less than making the building brick, stone or concrete, and the protection from fire is much superior, for in an unsprinklered fireproof building the contents will burn. But with a completely sprinklered wooden building, both the building and the contents are rendered practically fireproof. In addition, large sprinklered buildings, even of wooden construction, such as factories, warehouses, mercantile establishments, etc., outside of the congested districts, would help to check conflagrations in those areas where the value of a majority of the buildings is so low that a law requiring general sprinkler equipment would not be justifiable.

In addition to the physical improvements which I have outlined there are certain reforms in our laws relating to insurance and fires which would aid in preventing conflagrations as well as other fires. Overinsurance should be prohibited. I believe that it would be still better to allow insurance only to the amount of 85 or 90 per cent of the value of the property. Signed applications and a personal inspection by the local agent should be required, with a criminal penalty for misrepresentations. If overinsurance were thus made impossible, arson for profit would be prevented. Mr. Joseph Johnson, former fire commissioner of New York city, estimates that arson fires for profit cause from 25 to 40 per cent of the fire loss in greater New York.[a] A similar proportion exists in most large cities.

The publication in each State of a complete and plainly written book for free distribution in which all the various causes of the enormous fire loss and the means of fire prevention were detailed, would be valuable. This should be so prepared as to be available for instruction on these subjects in the public schools, which should be required by law.

Far surpassing, however, all other fire and conflagration prevention measures are the sprinklering and protection of all openings in all buildings in the congested districts of all cities. This will practically prevent conflagrations. The cost is not excessive and would be saved to the property owner in a few years through the inevitable reduction in insurance rates. It can only be accomplished by the enactment of proper laws in the different States. There is no other way in which this convention can accomplish so much good for the people of the United States as by securing such laws, and I urge that you take such action as will inaugurate the educational campaign which is necessary to secure the enactment of such legislation in all the States.

The Use of Cotton for the Production of Explosives*

THE history of the laboratory production of various forms of nitro-cellulose has been well stated by many chemists, and everything essential can be found either in their own researches or in the ordinary text-books. The practical outcome of such work has been the establishment of modes of manufacture for many purposes, but in the present instance it is proposed to deal entirely with the use of cellulose in one shape or another for explosives of any practicable kind. It is almost unnecessary to state here that every kind of propulsive explosive now used has cellulose as its basis, but it may not be superfluous to say that all military propulsive explosives have cotton for their basis as distinct from cellulose.

The word cellulose must not be understood in the strict chemical sense, but rather as including all those materials which are chiefly cellulose, and this definition will include materials like wood-pulp. Now one may clear the ground on this subject at once by saying that, for military purposes, wood-pulp and other impure forms of cellulose are useless. Very good sporting powder can be made from nitrated wood-pulp, but the artillerist would be in great difficulty if he were provided with such a propellant, because in order to obtain any sort of regularity the nitration of the wood-pulp has to be kept at a low point, and the ballistics on which the artillerist depends would be quite thrown out. The modern gun is really a machine of precision; the artillerist knows that and expects it to throw one shot after another to reach the same point within a fraction of its possible range as computed from its elevation of sighting, and his whole attention has been based on this. If he were supplied with a material, however good, which on explosion developed a lower pressure, he would be relatively helpless and his rivals, using their own standard material, would have him at a sore disadvantage.

In modern practice, the raw material used is cotton waste, which is, as its names implies, merely the rejected stuff in the manufacture of cotton goods; and although linters, which is the technical term for the short fiber material adhering to the cotton seed, may be used, yet its employment presents serious difficulties in that the seed with which it is associated has to be removed by chemical treatment. There have been many experiments made to use such substances as jute, ramie, kapok fiber, and in short everything from sulphite pulp to spun cotton, but as workable substances these have been rejected in favor of the staple material—cotton waste.

The method of producing a satisfactory form of nitro-cellulose from cotton waste is as follows: The waste is hand-picked so as to remove the grosser impurities. The product is teased, picked once more, and then dried. After that, the nitration process is carried out, and this has been much modified in the light of experience, but in essence still consists in the immersion of the purified waste in a mixture of nitric and sulphuric acids of the following composition: H_2SO_4, 71 per cent; HNO_3 21 per cent; H_2O, 8 per cent. The amount of water in this mixture is important, and the acids as they are written are as their formulæ represent and do not refer to the commercial products. The strict relationship of the water to the two active materials should be preserved. It is of course easy now to obtain sulphuric anhydride (SO_3) and make an anhydrous mixture, but this gives a nitro-cellulose with too high nitrogen content. After the mixed acids have acted for the required time, they are removed and the gun-cotton is washed to remove as much of the acid as possible, and purified by several boilings with water. The boiling with water is of great importance, as in this part of the process the unstable bodies produced during nitration are dissolved or decomposed, leaving the nitro-cellulose in a stable condition. The only thing now remaining is to pulp the cotton, which is again washed and then partly dried and moulded into the required shape by pressure.

The old idea that something as nearly as possible to the so-called hexa-nitrate of cellulose should be aimed at has been fairly well exploded, and the manufacturer seeks to regularize his output so that he may obtain a nitro-cellulose with approximately 11 molecules of NO_3 to the quadruple molecule, as shown in the formula $C_{24}H_{29}O_9(NO_3)_{11}$. This formula must not, however, be taken as any more than a convenient way of expressing the degree of nitration, which is really better stated in terms of content of nitrogen which ranges between 12.93 13.05. This is merely a parenthesis, but is necessary as showing how delicate and complicated a matter it is to obtain a uniform and trustworthy material for propulsive explosives, and as it has been found in practice that even what is apparently such a simple matter as the preparation of a mixture of acids of known composition is really one requiring some care and skill. It will be readily understood that the difficulty is trifling compared with that of providing an equally regular form of cellulose. So well is this recognized that different consignments of cotton waste, all of approved quality, all picked, teased and re-picked, are mixed so that the cellulosic raw material may be as nearly the same grade as possible.

With this fact in front of us, let us consider what the condition of a factory would be which had to use any kind of raw material, clean or dirty, lignified or not, and had to try to make that into a trustworthy propulsive explosive of standard quality. This question has only to be asked for the answer to provide itself. In the present case a great deal too much has been assumed as to the capability of our enemies for making trustworthy nitro-cellulose without cotton waste. Because any competent chemist in his laboratory could make some form of nitro-cellulose from his own shirt cuffs if he pleases, people have jumped to the conclusion that that will be of some use to the artillerist. The fact that the manufacturing process of an explosive like this is of the most delicate kind and has to be conducted with military precision, has been constantly overlooked; and at the present moment it is not too much to say that there is only one material available for modern gunnery, and that is cotton.

A NON-CORROSIVE alloy, consisting of iron, copper, boron and carbon, has been patented. It is hard and strong, and is easily worked.

[a] Review of Reviews, Vol. 45, p. 709.

* From *Nature*.

Boiler Corrosion and Scale to be Ended by the Use of Electricity*

IT was shown recently that the zinc used annually in the boilers of one ship was sufficient, if mixed with copper, to form brass to produce over 17,000,000 service rifle cartridges. It is almost impossible to calculate the stupendous number of cartridges that could be produced out of the zinc that is totally lost every year in the ships of the British Navy and of the mercantile marine, and in steam plants throughout the British Empire.

Whatever the total, it now seems clear that, thanks to the efforts of an Australian engineer, Mr. Elliott Cumberland, M.Inst.Met., there now exists no reason why a large proportion, if not all, of this total should not be saved, to the incalculable advantage of the country, and, incidentally, to the financial benefit of the owners of the steam plant.

By a very simple means, Mr. Cumberland appears to have succeeded in laying one of the biggest bogies that confronts the engineer—corrosion. His process is based upon the fact that all corrosion is the outcome of electrolytic or electro-chemical action. For years corrosion committees and private experimenters have been hovering round the solution of this problem. In a recent report by the Corrosion Committee of the Institute of Metals, the abandonment of brass for condenser tubes was advocated; it was suggested at the same time that greater attention might be paid to electrolytic methods of combating corrosion.

For many years, auxiliary plates of zinc, iron, or aluminium have been used with some effect in minimizing corrosion by forming a galvanic couple with the metal to be protected, and many users to-day persevere with this method; but it is a case of accepting the dawn for the day. Zinc, for instance, when used in this way requires constant attention, because if the zinc slabs are not frequently renewed they become a source of danger, and this is also the case when iron is used to protect brass and other metals. When new, the action of these auxiliary plates is for a time beneficial, because they are electro-positive to the metals they protect, but they are quickly transformed into zinc sulphates and iron hydrates, which are electro-negative, and it is obvious that when this occurs they join the attacking forces, and are doing more harm than good.

Mr. Cumberland's success can be attributed to bringing to bear permanently a stronger force than the one he desires to eliminate, and he introduces electricity from an external source, distributing this in the following manner: Metal anodes, suitably insulated, are fitted in the vessel to be protected and immersed in the water contained therein; a low-tension (dynamo generated) current, of a pressure not exceeding ten volts, is then supplied, this being regulated by suitable resistances fixed on a switchboard. The current most frequently used is from six to ten volts, and an ammeter is fitted on the switchboard, permitting the operator to adjust, by aid of the resistance, the amount of current supplied to any vessel or parts of it. The iron anode is connected (through insulated bolt) to the positive side of the circuit, the vessel being protected on the negative side, thus making it the cathode. When the current is supplied, the elements of the water in the vessel become electrically charged, and by the laws of electrolysis, the positive radicals, or anions, seek and assemble at the anode. Therefore, we find a film of hydrogen formed all over the immersed portions of the vessel, protecting it. The oxygen, acids, and other destructive agents are attracted to the iron anode which suffers from their attack, and in the course of time is reduced, and requires to be renewed. This can be done cheaply and expeditiously. By the use of this process the very parts that formerly suffered from deterioration through the corrosive effects of oxygen, acids, etc., in the water, are now protected, the forces of destruction being transferred from the receptacle itself to the inserted anodes, and any depleting currents which formerly existed are overpowered.

SCALE REMOVAL.

Further, besides preventing corrosion, this method removes all foreign matter from the immersed surfaces of the vessel, the reason being that the hydrogen is given off in minute bubbles on the surface of the metal—underneath the scale, grease or anything which may be adhering to it—and mechanically loosens such deposits; when the surfaces of the vessel are clean, the hydrogen given off prevents the setting of any solids. This cleaning effect is an important one, when one remembers that one tenth of an inch of hard scale causes a drop in fuel efficiency of as much as 10 per cent. Therefore, we are describing not only a method by which corrosive effects are prevented, but also one which, incidentally, removes all scale, grease, etc., and prevents further deposits. The application to the boilers alone of such a plant would be an asset, but when we realize the advantages of keeping the surfaces of our economizers clean and preventing the losses of tubes in the condensers, it is indeed seen to be one of the most remarkable strides in the progress of efficient maintenance of steam plant that has taken place for many years.

Further, the cost of electricity and of replacing anodes is ridiculously small, when compared with the prior cost of new tubes and laying off for repairs. It is not surprising, therefore, that owners and engineers of big concerns are displaying a lively interest in—what is to many—an entirely new process. It is also worthy of note that most of the leading shipping companies have installations on the boilers and condensers of their vessels, and numerous progressive firms in the United Kingdom have had their plants installed.

Prof. W. W. Haldane Gee, M.Sc.Tech.,B.Sc., had experiments to test the Cumberland process carried out at the Manchester School of Technology, these showing that the current densities necessary to protect iron, copper, and other metals from corrosion from fresh and salt water are of low value, and hence in the case of boilers and condensers the actual cost of the electrical energy required is a small item. The method, according to Prof. Haldane Gee, has proved effective not only in preventing corrosion, but also in removing scale from the heating surface and preventing its formation.

Recent remarkable results in the removal of old scale by this process have led to a series of interesting experiments and analyses, the object being to establish the exact chemical effects producing this result, and the nonformation of new scale when the boiler or other vessel is clean. The reports of these experiments are worthy of note.

There is every indication that the use of the process results, first of all, in the formation of minute portions of sodium, or in other words, sodium ions on the negative surface of the vessel protected. The sodium ions precipitate the gypsum and lime salts in the feed water, forming a finely divided deposit of calcium carbonate and oxide of iron, instead of the usual hard scale. Where the process has to deal with an old, hard scale, it apparently gets rid of it in the following manner: the gypsum existing in the scale is decomposed by the current and thus converted into a spongy state. The sulphate of calcium being gradually removed, the remaining carbonate of calcium expands and thus breaks away, being assisted in this by the hydrogen bubbles given off between the scale and the surface of the metal, by the reaction of the sodium ions with the water.

Besides showing how the Cumberland process may be of great potential value to the nation from a zinc saving standpoint, we have referred above principally to the prevention of corrosion and scale which it effects in boilers, economizers and condensers. But, it is only when one becomes practically conversant with the fundamental principles of this most important invention, the simple manner in which it operates, and with its many other possible applications, that the great future which must lie in store for it becomes apparent. The writer is confirmed in this view as a result of witnessing an ingenious and most convincing demonstration of the process, by means of working models, that is in operation in the city laboratory of the inventor.

* *London Daily Telegraph.*

Lining Mine Shafts

A NEW method of putting in the lining of mine shafts by using specially shaped concrete blocks, and building downward from the top, was recently described by Marcel Gillieaux at a meeting of the Mining Institute of Scotland.

A substantial crown ring is built into the standing rock at the head of the lining, and as the sinking proceeds concrete blocks of Z section are hung to the crown ring, the upper hook facing outward, while the lower hook faces inward, making the addition of further rings an easy matter. These blocks are segmental in form and are reinforced with double S hooks of bar steel, extending from the top to the bottom ribs, while additional hooked bars are introduced in the lip and throat sections.

After several rings of lining have been hung in this way, the opening between the lower ring and the shaft wall is closed, and the space between the lining and the walls is filled with a cement grout through openings left for the purpose, which binds the lining rings firmly to the external rock, and additional rings of blocks can then be safely hung to the lining above.

Such a construction affords much greater security to the workmen sinking the shaft than former methods of using temporary supports, and the cost appears to be satisfactory. Figures given for the lining of a circular shaft 18 feet in diameter through clay or schist, using blocks 7½ inches thick and 2 feet 3¾ inches on the inside arc length, with a height of 2 feet 6 inches and requiring twenty-four blocks to each ring, showed a cost of less than $50 per lineal yard.

ACCORDING to a paper on "Electric Steel-making Furnaces," read before the Manchester Branch of the Institution of Electrical Engineers on January 26th, 1915, there is really not much difference in the actual power needed when doing the same work in the different types of the better-known electric furnaces, and, in fact, when deciding on which type of furnace to install, the questions of the initial cost of the plant, its suitability for running off existing power supplies, the cost of repairs to the furnace, and the ease with which these can be carried out; are all points which are as important as the question of low power consumption. The size of the furnace, however, has an important bearing on the energy consumption, as the larger furnaces have a less radiating area as compared with the weight of the charge than smaller furnaces.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 23rd, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00

Scientific American (established 1845) . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

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